Making Climate Adaptation Work: Strategies for Resource Constrained South Asian Mega-Cities

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Abstract

This dissertation compares the responses of Dhaka, Bangladesh and Kolkata, India to the serious challenges posed by climate change, particularly in the water sector. Drawing on the theories of "adaptation as development" and cross-case analyses of ongoing planning initiatives in these two bellwether cities, this dissertation explores the factors that promote or hinder successful climate action. This work identifies practical, less resource-intensive adaptation strategies suited to the context of urban South Asia, where the findings suggest that, given the absence of dedicated adaptation planning at the city level, the most effective approaches are those that integrate both development and adaptation criteria. Resources allocated for local development can thus simultaneously address adaptation needs without substantial additional investments. Moreover, since such efforts are already part of ongoing planning initiatives, they obviate the need for more extensive "specialized adaptation" planning and technical expertise. These actions may thereby reduce the vulnerabilities of urban residents in these most threatened regions of the world.

Drawing upon over ninety in-depth interviews, primary documents, firsthand observation, relevant scholarship, and three emblematic, developmentally oriented project case studies that address the cities' most urgent climate risks in water, flood and wetlands management, this research proposes a "contingent adaptation" approach as best-suited to such resource-constrained environments. Such an approach has the ability to overcome inherent local *resource constraints*, *institutional limitations*, while increasing the *likelihood of adoption* of adaptation-oriented projects. This work identifies several factors—among them, developing collaborative partnerships to bridge technical deficits, reforming local organizational structures to generate internal resources, and building political consensus for climate action—as essential for successful climate adaptation. This work seeks to provide a theoretical framework for effectively implementing adaptation-related local planning initiatives while building broader support for substantial climate action. Such contingent adaptation approaches may thereby provide a blueprint for immediate, proactive, and cost-effective practical applications in similar cities in South Asia and in comparable developing regions.

Keywords: *Climate Adaptation, Mega-Cities, South Asia, Urban Planning*

To W--without him this work would not have been possible or life so beautiful. . .

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PROBLEM STATEMENT AND RESEARCH DESIGN

When it rains it pours ...

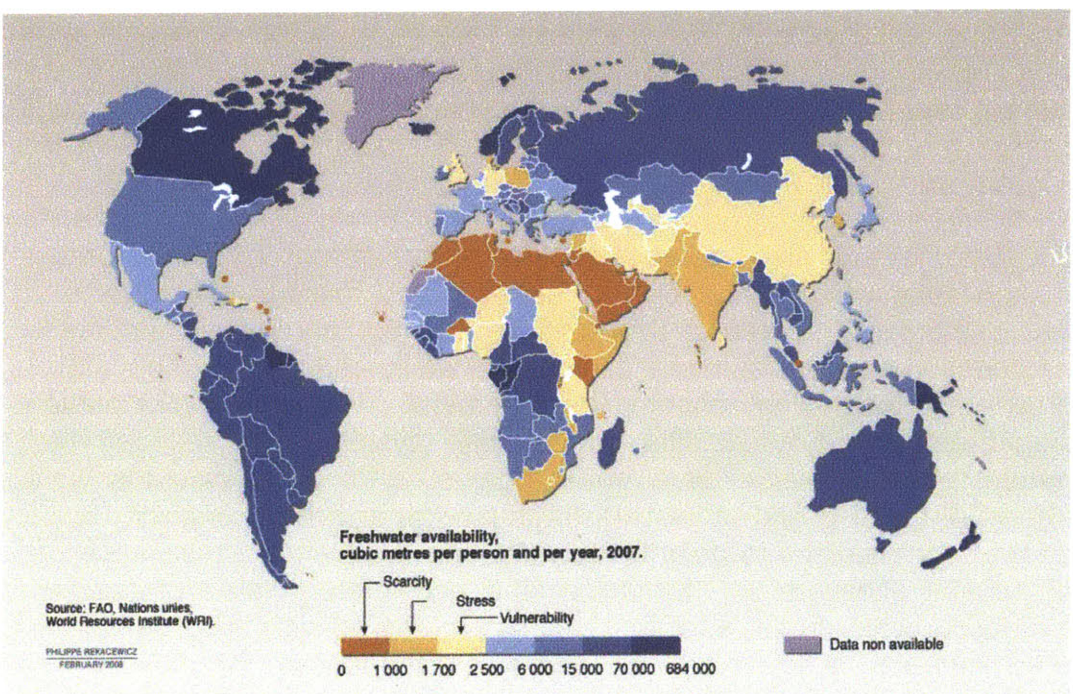
BACKGROUND

The world's scientific community has largely moved from merely establishing reasonable consensus on the reality of climate change to identifying the wide variety of impacts and embracing the need for concerted universal action. (Pielke Jr., 2005; Walther et al., 2005; Doran and Zimmerman, 2009; Oreskes, 2004) Researchers are increasingly focusing on the impacts of climate change on water resources and ecosystems. Conditions of rapid urbanization, poverty, and poor governance, as found in much of the Global South, greatly exacerbate the effects of global temperature and sea-level rise. Unfortunately, however, climate-change mitigation and adaptation efforts have been far less pronounced, and much less successful, in those regions, which are most at risk for catastrophic environmental repercussions. Nowhere is this challenge more fundamental than the issues in the water sector (Tangdamrongsub, Hwang, and Kao, 2011).

An overview of the recent literature highlights the obvious challenges in the water sector, while a closer examination reveals a complex set of interdependent issues associated with this problem. Inundation, contamination, irrigation, saline intrusion, and scarcity (both relative and absolute) represent some of the key issues arising from, or aggravated by, global warming. Where water is plentiful, as is the case in the tropical river basins of South Asia, the challenge will primarily consist not of ensuring a steady supply but rather of providing one that is safe for consumption (Bonell, Hufschmidt, and Gladwell 1993) and free from pollution and waterborne diseases (Shiklomanov, 1996; Shiklomanov, 1997; World Resources Institute, 1998 ; Gleick, 1998).

The scale of the problem of water supply is rising exponentially. By the year 2025, two-thirds of the world's population, projected to reach 8 billion, is predicted to live under "water-stressed" conditions (stemming from an imbalance between water use and water resources), while about 1.8 billion people will suffer from absolute water scarcity. In the subsequent decade, half the overall world population, or more than 4 billion people, will face water scarcity. (Food and Agriculture, 2007) Numerous causal factors, including population growth, agricultural reclamation, aquaculture, deforestation, and urbanization are contributing to the projections of water shortage. Many of these issues are independent of climate change; the water problems confronting much of South Asia have as much to do with patterns of use and with equity of access as with the accretive impacts of global warming. Climate change, however, does play an increasingly central role in shaping the physical environments of those areas at greatest risk, including South Asia. Irregular precipitation, higher temperatures, and storm-induced flooding all combine to degrade the quality and quantity of water available across much of the globe, compounding the effects of pollution and inefficient allocation.

FIGURE 1.1: Freshwater Availability across the world in 2007.
Source: FAO, WRI



As a result, climate adaptation, in various forms, is increasingly becoming part of the mainstream planning agenda in many regions of the world, more noticeably and effectively where conscious understanding of the severity of the threat merges with adequate resources—and effective institutions—to address these issues.

One crucial related concern is the state of the world's ecosystems, whose sustainability is intrinsically and interdependently linked with the issue of water resources. Disturbances in water cycles hasten the degradation of ecosystems, which in turn curtails the ability of the ecosystems to recharge and return purified water to the environment. This problem is already evident where extraction of groundwater and consumption of surface water as compared to recharge have exceeded the capacity for water renewal in numerous river basins around the world (Molle and Vallée, 2009). The degradation of ecosystems, especially wetlands, correlates strongly with areas of water stress across the world, notably in the Indo-Gangetic Plain of South Asia but also in many other areas (Arthurton et al., 2007). Diminishing potable water supplies and deteriorating ecosystems are thus intrinsically interrelated and mutually reinforcing, with devastating impacts on agriculture and human health.[1] Resulting water scarcity will doubtless have geopolitical ramifications as well. Tangdamrongsub, Hwang, and Kao (2011: 767) argue that, "If the current trend of EWH [equivalent water height] loss continues, a major conflict due to water resources is foreseen among the countries in the [Central and South Asian] region and its neighbors."

Ecosystems are also increasingly being threatened by development, human consumption, and climate change; according to the Millennium Assessment's 2005 report (MA, 2005), the "primary indirect drivers of degradation and loss of inland and coastal wetlands have been population growth and increasing economic development". The reduction or outright disappearance of floodplains and riverine systems has reduced their natural ability to serve as a buffer against or to ameliorate the worst effects of flooding and other catastrophic weather events, exposing many coastal communities to heightened risks and diminished subsistence use of coastal ecosystems. Moreover, the accelerating rates of resource extraction, water table reduction, and littoral degradation have deleterious environmental, economic, and social consequences far beyond the boundaries of any given ecosystem. Although global concern has focused largely on the disappearance of tropical rainforests, coastal systems are

[1] About three-quarters of all disease incidence in Bangladesh, for example, is directly attributable to water and sanitation problems (Chatterjee, 2002).

experiencing a 2% annual rate of degradation or destruction, versus 0.5% for rainforests (Bertsch, 2010).

This problem takes on an added dimension in the urban regions, especially in mega-cities, urban conglomerations with populations of over 10 million, a group that includes Asian cities like Tokyo, Jakarta, Seoul, Delhi, Shanghai, and Manila, according to current data (2012).[2] In such mega-cities, planners and policymakers must account not only for the impacts of global climate change, but also for the compounding effects of urbanization, which significantly exacerbates the complexity of the problem (Satterthwaite, 2009; Hammond, Gyau, and Adiaba 2012; Nelson et al., 2009). A catastrophic climatic event in a mega-city as opposed to a sparsely populated rural area could simultaneously threaten the lives of several million residents and potentially engender a series of devastating, cascading effects.

The problem is further worsened in cities of the developing world, where high population density, combined with lack of resources and coping capacity, makes the problem far more dangerous. One such city is Dhaka, the capital of Bangladesh, which serves as an illustrative example of just such a situation. The "city proper" of Dhaka encompasses a relatively small area of 815.85 km^2. However, by conservative estimates, in 2004 Dhaka had a population of 10-11 million people, a figure that increased to approximately 14.25 million by 2011 (Central Intelligence Agency, 2012). According to UN estimates, in Dhaka in 2004 about 4 million people lived in slums and shanties and several thousand lived on the streets, and these numbers are even larger today. Much of this vulnerable population lives in low-lying areas of the city, whose elevation ranges from only three to seven meters above sea level. The mean annual per capita income of Dhaka in 2009 was estimated to be $1,350 (USD), among the lowest of the world's mega-cities, with 34% of households living below the poverty line (Dhaka City Corporation 2000). In comparison, in terms of purchasing power parity, Dhaka's GDP is a small fraction of that of mega-cities in the developed world: New York has a per-capita GDP (PPP-adjusted) of over $57,000, Paris over $47,000, and Tokyo over $35,000. Moreover, Dhaka's population density is 44,400 per km^2, which makes it the most densely

[2] According to Demographia, World Urban Areas: 8th Annual Edition: Version 2 (2012.07), 26 cities across the world are now characterized as mega-cities, cities with a population of 10 million or more. Of these 26 mega-cities, 3 of them are in India (Delhi, Mumbai and Kolkata) and one in Bangladesh (Dhaka). For a list of all megacities please refer to page 16 of the report.

populated of the world's twenty-six mega-cities and further compounds the problems of climate change (See footnote 2). The case of the 2004 floods in Dhaka[3] highlight the many issues such cities face during extreme climatic events, challenges likely to multiply under the ongoing and intensifying effects of climate change. The 2004 floods were part of a series of major floods that have affected the city in the last two decades. More alarming, however, is that the *intensity* of these floods has risen dramatically, attributable in part to the effects of global warming.

During the 2004 floods, 40% of Dhaka, including nearly all of the city's main roads, was under water. Almost 600 people died and about 100,000 people suffered from waterborne diseases in the aftermath of the flood. The floods significantly impacted the lives of nearly 25 million Bangladeshis. The intensity of the floods was unprecedented; the fact that the city officials were not readily equipped to deal with such severe emergencies resulted in further suffering, as relief in the form of food, water and shelter was not able to reach the affected residents in a timely manner. Apart from the immediate dangers of the floods in the city, there were other related impacts that further complicated the situation and exacerbated the effects of the floods. The city's storm-water and sewer systems collapsed, as the infrastructure was inadequate for the heavy loads experienced. Because of the drainage system failure, much of the city was left waterlogged, and the system was unable to pump out the large amounts of water that left much of the city under water for weeks. About 341mm (nearly 13.5 inches) of rain was recorded in a single day—the highest recorded rainfall in 50 years–and temperatures rose above 35°C, which contributed to the spread of water-borne diseases in the aftermath of the floods, in addition to sewage contamination in the drinking water. Moreover, the city came to an economic standstill; the Dhaka Stock exchange was shut down and all businesses and food markets were closed, which also resulted in further economic losses and a lack of supplies for the millions of flood refugees.

The possibility of significantly greater impacts requires stronger defensive measures, which was not the case in Dhaka. The fact remains that in Dhaka, as in many of the highly vulnerable urban areas in the developing world, climate adaptation has not been part of the mainstream planning

[3] The account of the 2004 floods has been reconstructed from numerous contemporary news sources. See, for example, BBC News. http://news.bbc.co.uk/2/hi/south_asia/3654480.stm.

schema and a series of complex and interwoven social, political, economic, and institutional barriers more often than not create significant barriers to efforts to reduce vulnerability and enhance resilience in the face of climate change risks.

In contrast, many other mega-cities in the developed world, such as New York City, though faced with the many of the challenges of climate change, have formal processes to adapt to the effects generated by global warming.[4] Moreover, such cities also have favorable conditions such as lower population density[5] and significantly higher per-capita income, resulting in smaller percentages of vulnerable populations. Additionally, these developed world cities on average boast better infrastructure, somewhat greater political support for adaptation, more extensive technical expertise, and stronger institutional mechanisms to cope with climatic disasters.

In September 2004, New York City experienced flash floods linked to Hurricane Frances, representing a crisis roughly similar to that faced by Dhaka in the same year, which offers a useful point of comparison.[6] With two inches of rainfall every hour, topping out at 7 inches for a single day, the city's subway tunnels were flooded, as were some of the major thoroughfares and other secondary and tertiary roads, stranding tens of thousands of passengers. Despite concerted efforts led by the city's many governmental agencies, it took over twenty-four hours for the transportation networks, including the subway system, commuter rail, and public buses, to be restored. One of the major reasons for this delay was because the city's 720 drainage pumps, which were considered sufficient for most weather events, proved inadequate once the sewers and storm drains started overflowing, as there were no contingencies for draining out the excess water. However, the city's rapid responses to the crisis and otherwise strong infrastructure and resources, among other factors,

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[4] New York City, for example, has developed PlaNYC (discussed in greater detail below), a comprehensive strategy for managing climate change.

[5] According to the latest report of the Demographia World Urban Areas 2012, the population density of New York (the most densely populated city of North America) is $1400/km^2$, as compared to 44,400 in Dhaka in 2004; the figure for Dhaka has since increased.

[6] These floods resulting from Hurricane Frances were followed ten days later by torrential rains from Hurricane Ivan.

prevented the death or serious incapacitation of its residents. Despite the water-logging and unseasonably high temperatures, there were no further threats to public health.

Leaving aside issues of social inequality and theories of international relations, preliminary demographic data, in terms of population density and per capita income provide some common-sense conclusions as to the differences between mega-cities of the developing world and those of the developed nations in terms of the structural and adaptive mechanisms that characterize each category. Dhaka is a tropical, humid city and New York lies in a sub-tropical humid zone; both cities share some similar characteristics in terms of their weather, each with high summer temperatures and rainfall concentrated during two to three months of the year. Both cities also lie in earthquake zones and are subject to heat waves (New York City Office of Emergency Management, 2013) greatly exacerbated by their asphalt and concrete infrastructures, which traps heat by what is known as the "urban heat island" effect.[7] Climate-change-related predictions indicate significant sea-level rise for both cities as, like Dhaka, New York City is also in a relatively low-lying zone[8] with consequent magnified risk of flooding, storm surges, beach erosion, estuary salinity, and wetlands destruction (*Science Daily*, 2009).

In view of these past and projected climate impacts, New York City has taken a very proactive approach to Climate Adaptation Planning under the leadership of Mayor Bloomberg, who launched the Climate Change Adaptation Task Force in the summer of 2008. The Task Force, chartered through PlaNYC, New York City's long-term strategic blueprint for sustainable development, includes representatives from municipal, state, and private agencies responsible for infrastructure, water, sewer, power, and telecommunications services in the metropolitan area. The city's efforts are based on *concurrent* strategies: active mitigation measures to shrink the carbon footprint while adapting to environmental changes induced by climate change. The Adaptation Task Force of the city draws

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[7] The Urban Heat Island Effect is a condition where over time, certain urban areas experience a significant rise in their ambient temperatures, with means as much as 3 to 8°F (2 to 4°C) greater than those of the surrounding areas. The primary contributors to this phenomenon are overdevelopment and waste heat emissions.

[8] Recent predictions for New York City put the sea level rise at 18.5 inches for the metropolitan area by 2100, nearly double the worldwide averages. See Shepard et al. (2012) for a more thorough analysis of current risks to greater New York City.

upon the expertise of an Advisory Panel funded by the Rockefeller Foundation, as part of the Foundation's $70 million pledge to prepare cities for climate change. In order to support the Task Force's efforts, the Advisory Panel provides periodic data on climatic trends, threats to infrastructure, and best design practices, which further informs the development of city's comprehensive adaptation plan (Radley et al., 2011). In contrast, the city of Dhaka has yet to adopt a comparative city-level adaptation plan, though despite its numerous challenges it has made significant strides to make climate adaptation a priority at the national level and in various discrete measures and programs at the local levels, in fact more so than many of the other mega-cities in South Asia. The situation in Dhaka still nevertheless demands stronger action, especially when viewed against the steps taken in mega-cities in the developed world.

Hurricane Sandy, which devastated much of the East Coast in October 2012, made the weather and climate risks faced by New York City abundantly clear. Much of the "city that never sleeps" was effectively shut down for several days, and forty-eight city residents died in the storm, which caused over $60 billion in damage. Global warming means that New York will increasingly contend with many of the same threats as Dhaka and Kolkata: storm surges, saline intrusion, flooding, and water contamination. Within the first few months after Hurricane Sandy, New York State's NYS 2100 Commission issued a comprehensive policy statement (*Recommendations to Improve the Strength and Resilience of the Empire State's Infrastructure*, 2013) outlining the actions needed to enhance resilience and reduce vulnerability to climate-related weather events.[9] This report provides a strategic blueprint for climate-proofing New York City and surrounding areas, focusing on transportation, energy, land use, insurance, and infrastructure finance concerns.

While the report and complementary policies do not yet possess sufficient detail to evaluate the long-term effectiveness of the strategy fully, since Sandy occurred only four months ago, two features remain salient. First, the focus is on building resilience, rather than on merely enabling recovery (Castillo, 2013). This concern is shared as well in the new guidelines of the Federal Emergency Management Agency (FEMA), which now enable funding for rebuilding efforts that enhance the resilience of hard and soft

[9] To put New York's rapid response to Sandy in perspective, Dhaka only produced such a plan (DIFPP) more than three years after the floods of 1998 (which killed thousands and inundated two-thirds of the entire nation), and the plan was not fully implemented until 2011.

infrastructure (*Philadelphia Inquirer*, 2013). Second, these planning efforts are designed specifically to address weaknesses across several sectors simultaneously. The effects of Sandy demonstrated the need to recognize the interdependent nature of various systems and to develop "truly robust regional network of built and natural infrastructure, local and state institutions, and information and communication systems" (NYS 2100 Commission, 2013: 32). While it remains to be seen whether this laudable set of policies will translate into effective action, the response to date has been swift, comprehensive, and forward-looking, especially compared to the response of Dhaka and Kolkata to similar events. For example, the Dhaka Integrated Flood Protection Plan (DIFPP) only commenced three years after the devastating floods of 1998. In Kolkata, the situation seems even more lax; even after the devastating impacts of cyclone Aila in 2009, the city is yet to create an effective disaster management plan.

It is important to note that New York City's abundant resources and broad commitment to environmental protection have enabled planned, anticipatory adaptive responses to climate change. The primary strengths of New York City's approach lie in the clear lines of responsibility, overarching, long-term vision, and institutionalization of its adaptation policy. The city has adopted a framework and set of approaches that correspond well to its strengths and to the context of the developed world.[10]

The progress that New York has enjoyed to date—though the city still has a long way to go in embracing climate-change adaptation—is admirable,

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[10] The *New York Times* (Navarro, 2012) provides interesting updates and scientific opinion from involved planners, policy analysts, and engineers working on the City's climate change Initiatives. Though the article has high praise for Mayor Bloomberg's commissioned extensive research on Climate Change, which has spurred new sets of activities such as expansion of urban wetlands and installation of green roofs, critics say that the adaptive measures are inadequate to protect the city. Though there is wide agreement that the city is extremely proactive in it's adaptive efforts—the overall analysis points to the fact that the measures being taken are too slow to address the immediate and impending threats of climate change. Moreover, the city's waterfront is still being developed to a large part "as is", without consideration of sea-level rise. In the industrial waterfronts of the city, where chemical-manufacturing plants, oil-storage sites and garbage-transfer stations are located, the dangers are amplified as storm surges and floods could potentially expose hazardous materials into the waters.

but also somewhat expected. In South Asia, however, the problem of adapting to climate change is certainly among the most crucial for the region. Much of the world's rapid urbanization is occurring, in historic proportions, in this area, and the region's municipal authorities are far less equipped to deal with such extraordinary changes. By the end of the next decade (2020), five of the world's eleven mega-cities—those with a population of at least 10 million—will be in the South Asian region (Kraas, 2007). South Asian mega-cities such as Delhi, Mumbai, and Dhaka will each contain over 20 million people, while Kolkata is projected to grow to 15 million residents (by conservative estimates) and become the world's eighth-largest city. These cities' residents, along with two billion others who live in low- and middle-income countries, are facing escalating risks from the numerous, interrelated environmental, economic, and societal impacts of climate change (Satterthwaite et al., 2007).

TABLE 1.1: Ranking of top 20 cities in terms of population exposed to coastal flooding currently, and in the 2070s (exposure to both climate and socioeconomic changes) Source: (Nicholls et al., 2007)

Rank	Country	Urban Agglomeration	Current Exposed Population	Future Exposed Population
1	India	***Kolkata (Calcutta)***	**1,929,000**	**14,014,000**
2	India	Mumbai (Bombay)	2,787,000	11,418,000
3	Bangladesh	***Dhaka***	**844,000**	**11,135,000**
4	China	Guangzhou	2,718,000	10,333,000
5	Vietnam	Ho Chi Minh City	1,931,000	9,216,000
6	China	Shanghai	2,353,000	5,451,000
7	Thailand	Bangkok	907,000	5,138,000
8	Myanmar	Rangoon	510,000	4,965,000
9	USA	Miami	2,003,000	4,705,000
10	Vietnam	Hai PhÒng	794,000	4,711,000
11	Egypt	Alexandria	1,330,000	4,375,000
12	China	Tianjin	956,000	3,790,000
13	Bangladesh	Khulna	441,000	3,641,000
14	China	Ningbo	299,000	3,305,000
15	Nigeria	Lagos	357,000	3,229,000
16	CÔteD'ivoire	Abidjan	519,000	3,110,000
17	USA	New York-Newark	1,540,000	2,931,000
18	Bangladesh	Chittagong	255,000	2,866,000
19	Japan	Tokyo	1,110,000	2,521,000
20	Indonesia	Jakarta	513,000	2,248,000

Various factors, including extreme poverty, high population densities, and unstable climatic conditions—sea-level rise, salt-water intrusion, floods and cyclones—exacerbate the environmental dangers[11] confronting South Asia, and "impacts ranging from higher temperatures to more variable precipitation and more frequent extreme weather events are expected to intensify."[12] The acute climate risks facing South Asia thus make it imperative to adapt to the environmental danger's confronting its cities. Although not the principal focus of this work, the potential impacts of these acute risks on agriculture and aquaculture alone are daunting, in a region in which most people still depend on subsistence smallholding and farming and in which caloric intake averages less than 2200 per day, 59% less than that of the US.[13]

ADAPTATION EFFORTS IN SOUTH ASIAN CITIES

Only a few cities in South Asia have formal climate resilience action plans at the local level; notable among them is Surat in the state of Gujarat, India, whose initiatives are supported by the Asian Cities Climate Change Resilience Network (ACCCRN). Some of the other cities in South Asia have also taken the first steps towards formulating climate resilience and vulnerability reductions strategies. Two major international initiatives are the primary drivers for these cities; the first is the Asian Cities Adapt project (ACA), which was initiated in February, 2010 and is scheduled to run through August 2013. ACA operates under the umbrella of ICLEI, the Local Governments for Sustainability Program, and currently supports four cities in India—Kochi, Madurai, Howrah[14] and Vishakhapatnam and another four in the Philippines—San Fernando, Tuguegarao, Baguio and

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[11] By the year 2050, in the cities of Kolkata and Dhaka, saltwater intrusions caused by rising sea levels are estimated to penetrate over 100km into fresh water estuaries, while the projected population dislocations from flood-related events in Bangladesh alone are estimated to affect over 17 million people (Akter, 2009).

[12] As noted by Richard Damania, World Bank Lead Environmental Economist for the South Asia Region, at the United Nations Climate Change Conference in Copenhagen, Denmark.

[13] Data retrieved from the World Development Indicators Report (World Bank 2012) http://data.worldbank.org/data-catalog/world-development-indicators, accessed on 9/15/2012.

[14] Howrah is the twin city of Kolkata, located on the west bank of the Hooghly River, and has a population of approximately 1.2 million.

Dagupan. All these initiatives are currently in varying stages of preparing climate adaptation plans; some have identified and begun to engage groups of stakeholders for this process in addition to conducting local vulnerability assessments. The second international climate adaptation effort that focuses on Asian cities is the aforementioned ACCCRN, which was launched in 2008 by the Rockefeller Foundation. The ACCCRN is a seven-year initiative with a budget of $59 million and focuses on addressing various impacts of climate change and urbanization, particularly its effects on the poor and other vulnerable communities. Currently the ACCCRN network consists of ten second-tier cities (populations less than 10 million but expected to grow rapidly) across four South and Southeast Asian countries: India, Indonesia, Thailand and Vietnam.[15]

It is noteworthy that most of the "formal" climate resilience planning measures in which these cities are currently engaged have been primarily initiated and supported by international agencies rather than the municipal governments, although these governments have, in a few instances, become involved later in the process. In some cases, the local municipalities are yet to become involved and many of the primary stakeholders engaged in adaptation planning consist largely of local community members, NGOs and universities. The principal challenge for international organizations is therefore mobilizing engagement on the local level.[16] More important, a majority of these cities do not even have climate-adaptation plans; if at all, the primary focus in their climate action plans remains on mitigation or, simply stated, the reduction of greenhouse gases.[17]

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[15] Thomas (2009), for example details some of the resilience-building efforts of ACCCRN in Surat, Gujarat.

[16] Hjerpe and Glaas (2012), for example, argue that incorporating socioeconomic stresses into vulnerability assessments can be quite effective in generating local involvement in adaptation.

[17] Delhi is the first city in India that has formulated a separate Action Plan for Climate Change based on the Indian National Action Plan for Climate Change. However, as is the case in Coimbatore and Rajkot under the UCP, the Climate Action Plan is largely mitigation-oriented at this point; one of the primary initiatives underway in Delhi is the quantification of mitigation interventions.

The approach under the Urban Climate Project (UCP) initiative, however, in this respect is markedly distinct from that of the ACCCRN and the ACA programs. Spearheaded by ICLEI, UCP is founded on a partnership with the Government of India; the overall strategy consists of introducing climate resilience aspects into already ongoing or planned projects. Also unlike the ACCCRN and ACA programs, UCP's primary funding is through the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) scheme, which is planned and implemented by the Indian government, rather than through international development agencies.[18] Drawing upon the organization's collaborations with municipal governments throughout Asia in the past, ICLEI has found that some of the primary barriers to incorporating climate change activities into municipal planning stem from lack of awareness and technical expertise and support rather than from a lack of options. Operating under this premise, UCP's overall agenda is to integrate climate-change resilience into planning by offering complementary options and providing technical know-how and expertise for already planned and funded infrastructure projects under the auspices of the JNNURM. Since late 2009, the UCP has begun implementation in two pilot cities of India, Rajkot and Coimbatore (again second-tier cities), and projects primarily focus on "mitigation-heavy" options such as energy savings and emissions reduction with efforts underway to create water savings and to expand waste water reuse. Supported by the JNNURM budget allocation of $200 million over the next five years, these projects have shown early promise, as there is significant local municipal government support and engagement as well as broader political involvement. The overall goal is to take these JNNURM-UCP activities and use them as pilot projects to identify best practices and disseminate the conclusions to a large cross-section of similar urban environments.

Such efforts to draw upon resources, expertise, and policy at the national and international levels, while utilizing local agencies to modify and implement adaptation measures, require careful consideration of intergovernmental relations. Historically, both India and Bangladesh have relied fairly heavily on national policymaking and control (Surjan and Shaw, 2009). The global trend since the 1980s, however, has been to reduce the role of central governments in planning and development efforts, under the "New Public Management" approach, through decentralization and devolution of authority upon local and non-state entities (Samaratunge, Alam, and Teicher, 2008). This approach relies on

[18] The US Department of State, however, does provide some financial and technical assistance to the project (*United News of India* 2009).

market forces, civil society actors, and NGOs to implement responsive, cost-effective policies. New Public Management has been successful in certain developed nations, where "the advanced level of economic development, the existence of a formal market economy, the rule of law, the advanced level of administrative infrastructure and state efficiency for the success of NPM-oriented reforms" are present (Abu, 2006: 180). Several studies, however, have demonstrated that New Public Management approaches have worked poorly in developing nations such as India and Bangladesh (see, for example, Surjan and Shaw, 2009; Abu, 2005; Eakin, Eriksen, Eikeland, and Øyen, 2011). Nevertheless, policymakers in both India and Bangladesh have embraced these methods in an effort to increase efficiency and tailor policy solutions to local priorities. These methods, however, are generally ill-suited to developing nations in general, and India in particular (Caiden and Sundaram, 2004).

My research shows that without national or international support and guidance, cities often fail to achieve their adaptation aims. Local direction of such efforts, however, does bring tangible benefits, including the engagement of local stakeholders, since "participation in decision-making, access to knowledge and other resources, and the responsibility of decision-makers to constituencies are issues of particular salience to adaptation" (Eakin et al., 2011: 341). Moreover, locally led projects offer greater opportunities for addressing multiple objectives in individual measures, as "the challenge for developing countries is to streamline and integrate climate change adaptation programs" (Onzivu, 2009). Finally, adaptation efforts at the city level enable more targeted measures to be implemented that take cognizance of local conditions and resources (Djoghlaf, 2007). Local actors, however, in most cases, nevertheless require support, guidance, and oversight from higher-level entities to be most effective (Oda and Shoji, 2010).

Although the approaches taken by ACCCRN, ACA, and UCP offer hope for success on a limited scale, overall crucial doubts remain both in the scholarly and scientific community as to whether the plans adopted by various South Asian cities can tackle complex, interdependent climate-related risks and be effectively implemented.[19] Currently, neither

[19] Financial, technical, and especially political difficulties effectively forestall climate-change planning efforts in India. The city of Chennai, for example, commissioned a comprehensive, well-received Climate Change Action Plan, prepared jointly by researchers from Madras and Kyoto Universities. The city's Corporation Council,

"adaptation" nor even planning for climate change in general is part of the vast majority of environmental planning considerations in the developing world. Such considerations have been largely subsumed under the umbrella of planned urban development of mega-cities, rather than as a separate area of concern. This current situation further erodes confidence in the ability of the existing strategies and institutions to engender effectual results when adapting to climate change, especially in the resource-constrained mega-cities of South Asia, where the primary focus of local planning authorities remains on economic development.

Numerous opportunities for effective adaptation measures, which are less resource-intensive and can be integrated into current and planned initiatives, do exist, however. The water and ecosystems sectors, for example, offer several possibilities:

Water Sector:

- *Surface-water treatment plants.* The broader utilization of surface water brings several complementary benefits, including diminished reliance on groundwater (reducing sub-surface salinity), lower river levels (decreasing vulnerability to riverine flooding), and smaller insect populations (limiting vector-borne disease). Such an approach to ensuring safe water supply can also be a very cost-effective one (Bieker, Cornel, and Wagner, 2010). This component, however, requires planners to "develop effective methods for incorporating appropriate community consensus and aspirations into major changes in water supply systems subject to climate change" (Short, Peirson, Peters, and Cox, 2012: 1957)
- *De-siltation of canals and sewer systems.* A major cause of water-logging is the inability of flood waters to drain out of the city after monsoon rains. While the current drainage infrastructure is insufficient in the long term, its performance in the near term could be significantly enhanced through maintenance measures (Miah,

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however, was yet to ratify the document (in 2011) after municipal elections brought a new mayor to office last year. Similarly, the city of Delhi established an Energy Efficiency and Renewable Energy Management Centre in 2008, but the capital municipal governing authority did not name a Director for over two years. The Centre's lackluster accomplishments to date include a series of largely unenforced energy and development guidelines and a three-page set of energy-saving recommendations for residents. The principal driver of such efforts in Delhi is the city's chronic power outages, rather than concerns over climate change, however (Hoornweg et al., 2011).

Bari and Rahman, 2010). Siltation, by reducing water flows, also hurts aquaculture and agriculture.

- *Rainwater harvesting.* The intensity and concentration of precipitation in the region and cost effectiveness of harvesting, coupled with persistent issues of water supply and quality, make rainwater capture and use an ideal adaptive mechanism. Since such methods are not yet widely accepted, largely for normative reasons (Inauen, Hossain, Johnston, and Mosler, 2013), such an autonomous adaptation holds strong promise.

Wetlands Sector:

- *Curtailment of illegal wetlands encroachment.* Urban wetland areas, whether scattered throughout the city (as in Dhaka) or primarily on the city margins (as in Kolkata), provide several adaptive benefits. These include serving as catchment areas (reducing the occurrence, duration, and intensity of inundations), enabling agriculture and aquaculture (promoting economic and food independence), and purifying runoff through recharging (increasing water quality). Such measures, however, entail serious consideration of conflicting priorities among local and national stakeholders (Narayanan and Venot, 2009; Chinitz, 1990), where the wetlands represent high value real estate for development.
- *Pursue Integrated Water Resource Management (IWRM) objectives.* Since complete conservation, in current form, of wetlands is politically infeasible, combining preservation efforts within coordinated development efforts enables cities to realize the adaptive benefits of wetlands while allowing for necessary economic growth (Stefano, 2010).

SYSTEMIC FACTORS THAT CONTRIBUTE TO CLIMATE RISKS

Three further and perhaps even more pressing factors combine to exacerbate the situation in Asia's mega-cities. The first is the rapid rate of urbanization, which has spawned rampant and increasingly unsustainable development. The second is the inherently weak institutional capacities of these cities and the concomitant inability of planning agencies to operationalize and implement effective adaptation plans. The third aspect is the acute resource constraints that these cities face: the bulk of national and city expenditures are channeled toward the provision of basic necessities such as food, electricity, and water. Climate-adaptation funding is thus not a priority for most cities in this region.

Urbanization

The two principal components of increasing urban population, natural growth and in-migration, have both contributed to the creation and expansion of the world's mega-cities, resulting in extreme urban concentrations (Berry, 2008). [20] This phenomenon, further fueled by related mega-urban development processes, is far more pronounced in the developing world. Concurrently, the geographical boundaries of cities are rapidly expanding as well to accommodate more and more people[21], exacerbating the impacts of the intertwined processes of in-migration, high birth rates, and diminished infant mortality; two thirds of the world's mega-cities are now in the developing regions of East and South Asia and Africa (United Nations, 2004; Kraas, 2008; Bronger, 2004). It is estimated that in the next two decades, South Asia will encompass a majority of the world's mega-cities. Though this growth has engendered many positive changes in the economic, political and socio-cultural arenas[22] of these mega-cities, it has also created areas of high global ecological risk.

On the anthropogenic spectrum, socio-economic vulnerability and political-institutional fragmentation are two of the primary contributors to the deterioration of mega-cities. The first is the increasing poverty of these conurbations, an obvious reflection of which is the growing number and population density of slums. The second is the devolution of responsibility, in a majority of cases, from provincial and national authorities to already weak (and poorly funded) local governments. Such decentralization has created a market-driven approach to basic welfare services and supply of public goods (particularly in South Asia); access to basic services such as potable water and rudimentary sanitation has significantly trailed behind despite rising incomes, thereby exposing increasingly large segments of the population not only to chronic long-term health hazards, but also to more immediate threats to survival. Jin and Sun (2011), for example found that decentralized structures actually greatly diminished urban

[20] Dhaka, for example, now accounts for over 35% of the entire population of Bangladesh, up from about 34% just eight years ago (World Bank, Databank, 2012).

[21] See Mohan, Subhan, Narendrareddy, Kandya, and Pandey (2011) for a discussion of this process in Delhi.

[22] Access to amenities such as education, basic health care, sanitation, law enforcement, varied types of employment, technology, and cultural enrichment certainly accompany increasing urban concentration, but these benefits are unevenly distributed, more markedly so in the Global South.

public-health outcomes, such as infant mortality, in contrast to expectations. Furthermore, even those who tout the benefits of decentralized control for the water sector (e.g., Daigger, 2009) recognize that the technologies needed for its efficient employment (e.g., membrane filters) and loss of economies of scale make decentralized approaches less effective in developing regions.

Increasing levels of atmospheric pollution in mega-cities is fast becoming a global health concern; chronic ailments such as asthma and bronchitis, and alarming numbers of fatalities from carbon monoxide and ozone poisoning are but few of the effects of this. In addition, unsafe drinking water, lack of sanitation and overall unhygienic conditions, especially in slums of the developing world, have increased the threat of water- and vector-borne diseases such as dysentery, cholera, malaria, dengue fever, schistosomiasis, hookworm, Lyme disease, filariasis, and tuberculosis. Vector-borne diseases currently account for 1.1 million deaths annually, and water-borne diseases kill 1.7 million annually, over 90% of whom are in the developing world (Ezzati et al., 2005). Increasing heat, humidity, and flooding play a particularly important role in providing breeding grounds for mosquitoes, with cases of dengue fever expected to rise by over 2 billion by 2080 (Hales et al., 2002). Climate models predict a 300% increase in category-5 cyclonic activity within the same period, which in turn will significantly heighten the risks of such water- and insect-borne diseases (Knutson and Tuleya, 2004).

Ecologically, these cities are also facing grave consequences because of urbanization. Excessive spatial expansion characterized by unregulated, unplanned and ungovernable development has not only damaged much of the urban wetlands, destroyed water bodies, and clogged natural drainage channels, but counterproductive development—either because it is too extensive or of an environmentally destructive nature—has also amplified effects of urban heat-islands and increased surface water run-off. These effects in turn greatly reduce groundwater recharge capacities, leading to severe strain on the water sector among other related consequences. Moreover, external climatic events, potential health outbreaks, air pollution, and contamination of ground and surface water bodies, in concert with crumbling, outdated and in most cities inadequate infrastructure, pose a difficult challenge in planning for these growing mega-cities. Urban areas therefore both fall victim to, and themselves inherently engender and reinforce, these deleterious consequences of population concentrations (Mitchell, 1999).

Institutional Capacity

Much of the urban research in the past few decades points to the gradual attenuation of the scope and effectiveness of public-sector service delivery in most South Asian countries; the problem of weak institutional capacities increasingly represents a major barrier to effective urban management of the region's cities (Graham 2009; Dodman and Satterthwaite 2008; Farazmand 2009; Rice and Patrick 2008; Campbell 2009). With the rise of neo-liberalism in the 1990's, decentralization in governance has taken center stage in many policy experiments in numerous countries across the developing world, including India, China, the Philippines, Uganda, and Brazil. This decentralization occurred largely within a unitary governance structure with little variation across "developing" regions, principally from a desire for more rapid economic development. Decentralized decision-making, it was assumed, would create proactive, agile, and responsive governance and in turn allow for an effective system of allocation across the board, thereby filling the Global South's crucial "capacity gap" (Evans 1997). Operating within the framework of newly liberalized, market-driven economies, devolution of power to local institutions seem to hold greater promise for economic growth, participatory planning, and safeguarding of local interests, including environmental concerns. In contrast, however, in most cases it has led to weak local governmental institutions. Recent studies across the developing world have highlighted some of the pitfalls, such as, the potential for poorly coordinated regional policy initiatives, insufficient local resource transfer and capacity, and the risk that local elites may hijack projects to further their own agendas (Azfar et al., 2001).

In terms of urban management of climate-change adaptation, with which this research is principally concerned, the weak institutional capacities of many local governments represent a severe limitation. In this area, even though the central or state governments have devolved the authority to carry out policies upon the relevant local public agencies, these organizations are often unable to fulfill their responsibilities effectively for a host of reasons. Successful urban management, especially in rapidly growing mega-cities, requires accurate appraisal of the magnitude and nature of the adaptations required, so that authorities can allocate corresponding resources, provide sufficient institutional and human resource capacity, and craft solutions of a suitable scale (Devas and Rakodi, 1993). However, in practice, these institutions do not have the necessary technical expertise, human capacity, financial allocation or even regulatory power to manage the cities. The major governmental failures of the Global South, namely, systemically ingrained corruption, insufficient transparency, and lack of accountability, make matters even worse.[23] Additionally, unnecessarily complex demarcations of institutional power and authority, coupled with the resulting inertia related to the "opportunity costs" associated with institutional collaborations, further restrict the overall capacity of these governing bodies (Tole, 2010).

Perhaps one of the most problematic impacts lies in the conflict generated between the immediate interests of local governments and broader strategic aims at the level of provincial or national governance. This condition is especially acute in the case of many rapidly urbanizing countries, where the economic growth of particular cities is often pursued at the expense of larger policy goals, such as environmental policy, affordable housing provision, and water and waste management. Moreover, the various costs of large-scale urbanization are often prohibitive, beyond the available resources of cities themselves; in the Global South, the unavoidable reality of rapid city expansion must therefore be factored into broader development strategies and supported by regional and national governments in order to overcome the weak capacity of local government actors (Hassan and Zetter, 2002). Failure to do so too often results in catastrophic environmental consequences, as policymakers at the local level often end up "kicking the can down the road," eschewing hard choices while suffering from managerial, technical, and financial limitations, worsened by corruption and local influence.[24]

(Kantor, 2007) argues that the effects of global competition are more keenly felt at the local and urban levels than at national ones, exacerbating the pressures on cities to create conditions favorable to industry siting and expansion of employment opportunities. This situation is particularly endemic in resource-constrained developing countries where weak local institutions often have the competing agendas of

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[23] Peisakhin (2012), suggests that public activism (through, for example, India's Freedom of Information legislation) brings results that are almost as effective as those accruing from bribery, but recognizes that such approaches require an informed, activist population.

[24] Wang, Ran, Wang, and Shi, (2009), for example have found excessive waste and poor performance under conditions of decentralized management in China, while others (Ullah and Pongquan, 2010; Ingham and Kalam, 1992;) identify similar problems in India and Bangladesh. Haque (2008) points to the extreme social divides that characterize South Asia ("class, caster, and gender") as key factors in the failures of decentralization.

economic development and environmental sustainability, while simultaneously trying to ensure equity. That these goals of growth and environmental protection stand almost universally in conflict in the Global South, makes planning and policy formulation regarding longer-term strategic priorities such as sustainable development even more complex and suboptimal. Thus, one of the principal arguments made to advance decentralized approaches to governance—that of the responsiveness of local authorities to the concerns and priorities of residents—falls away in the context of environmental policy, insofar as city-level leaders in the Global South, invariably emphasize economic development (Estes, 2007).

Resource Constraints

Moreover, resource constraints in the developing world have been cited as one of the primary barriers to development, particularly equitable development. In absolute terms, resource constraints can be measured in the GDP disparity between mega-cities. New York, for example is one of the wealthiest mega-cities of the developed world and ranks highest in terms of GDP of North American cities with an annual GDP of $1406 billion in 2008 (PricewaterhouseCoopers, 2009). In contrast, although India is considered a low-middle income country by UN definitions, Mumbai, one of the more prosperous cities in the developing world, has a GDP of only $209 billion, though its population is comparable to that of New York.[25] As staggering as GDP comparisons between mega-cities of the developed and developing world may be, there are also significant disparities among cities located within the developing world itself. The city of Dhaka, though it ranks highest in terms of its GDP among low-income countries, had a GDP of only $78 billion in 2008, whereas Kolkata,[26] which does not even rank among the top five cities in the low-middle income bracket countries, had an annual GDP of $104 billion. These significant variations have enormous consequences for the ability of these poorer urban areas to consider, let alone act upon, policy initiatives that are *perceived* to hinder economic growth in pursuit of environmental goals. While the important distinction between "economic development" and

[25] According to 2008 population estimates from the UN, Mumbai has a population of 19.35 million, roughly the same as New York's population of 19.18 million.

[26] Kolkata is projected to be the seventh-largest conurbation, on par with New York City, by 2025.

"economic growth" (Daly, 1996) is gaining traction in the West, it is not yet part of policymaking or political discourse in the Global South.

These resource constraints have numerous direct and indirect implications for many aspects of urban planning. In the case of mega-cities, particularly in South Asia, the choice and scope of projects is often dictated by each city's immediate developmental and economic aims, a situation exacerbated by the relative paucity of resources available for planning initiatives. The overall planning focus is on developing, upgrading, and expanding basic infrastructure to provide necessary services such as safe water supply, sanitation, housing and energy; even these more immediate and modest objectives, however, remain partly or wholly unfulfilled. For example, in urban areas of India and Bangladesh in 2010, only 48% and 20%, respectively, of urban residents had water piped to their domiciles, and merely 57% and 58% had access to improved sanitation facilities (WHO/UNICEF, 2012). By the year 2030 the deficit in urban services is expected to escalate even more. In India alone, the gap in water supply in the time frame between 2007 and 2030 will increase 3.5 times, in sewerage the deficit in infrastructure will double and for solid waste services it will quadruple (McKinsey Global Institute, 2010). The escalating need for additional infrastructure for the water sector, however, offers possibilities for integrating climate adaptation into development activities, especially where this can be accomplished with little or no additional initial outlay.

Rapid economic development is another dominant driving force for planning projects in South Asian mega-cities. City-level resources are diverted to projects that offer the prospect of expanding employment and tax revenues before they are allocated to address systemic inadequacies in basic infrastructure. Political pressure, coupled with a pervasive belief in the redemptive power of economic growth, helps to generate this counterproductive pattern of prioritization. The development initiatives that assume precedence in the allocation of infrastructure resources are primarily intended to attract national and foreign direct investment; such initiatives range from constructing high-speed toll roads to upgrading telecommunication infrastructure, from developing and beautifying office parks, to building mega-mall complexes. Too often, these projects incur large social and environmental costs, intensifying income inequalities and magnifying the strain on the cities' overtaxed infrastructures. Not only do the poor and vulnerable elements of the population bear the brunt of the negative impacts arising from such development,[27] but also local governments often feel compelled to provide tax breaks and relax environmental considerations to attract investment. This focus on short-term economic gains (at the expense of social, environmental, and long-term economic costs) reflects a prevailing "zero-sum game" mentality with regard to economic development.

Another drain on the already overtaxed municipal resources is the systemic corruption endemic in many countries of the developing world. Projects are delayed or stalled, construction takes place under unsafe conditions or in violation of building codes, and budgets are inflated exponentially because of corruption at various levels. According to Transparency International reporting for 2011, the perceived level of public sector (administrative and political) transparency in India is 3.1 and that of Bangladesh is 2.7 (out of a maximum score of 10), indicating that both countries suffer from remarkably high levels of public-sector corruption.[28]

Resource constraints also affect the nature and scale of climate adaptation. Planning for climate adaptation needs to take into account multiple wide-ranging, cascading, and overlapping effects relating to both socio-economic and climatic conditions. Planning efforts, however, are often hindered by a large number of related factors, such as institutional stagnation, technological and human capacity deficits, inadequate municipal governance, unclear organization and delegation of responsibility, ineffective implementation strategies, and limited financial resources. Moreover, the competing, often conflicting interests of market, state, and civil society actors (Sanyal, 1991) coupled with limited local capacity and transparency, further reduce the efficacy of the planning process and hinder the realization of even the most modest of planning objectives.

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[27] Such impacts include escalating food and housing costs, urban congestion, reduced public transportation carrying capacity, and curtailed access to potable water and electricity.

[28] According to a Transparency International report from 2011, public sector corruption has been measured "on a scale of 0 - 10, where 0 means that a country is perceived as highly corrupt and 10 means that a country is perceived as very clean". 183 countries and territories assessed in 2011 received scores lower than 5. India ranked ninety-fifth in the survey, while Bangladesh was ranked at 120. For comparison, New Zealand (9.5) was ranked highest, while the US (7.1) was 24th.

In absolute terms, many of these municipal bodies have very limited budgets; making matters worse is the fact that financial allocation for projects related to climate adaptation is not a priority. According to the Office of Budget and Management of New York City[29], for FY2011 the city budget topped at $47 billion. In comparison, for the city of Kolkata, the Kolkata Municipal Corporation (KMC) (a body responsible for delivering a wide range of city services, infrastructure maintenance, and development as well as for planning) has a proposed budget of INR 2294 crore (approximately $417 million) for the year 2011-12, according to the Office of the Mayor.[30] In addition to this the Kolkata Metropolitan Development Authority, which also has shares and supports some of the city planning functions of the Kolkata City proper and greater Metropolitan Area, had a budget allocation of INR1211.94 crore (or about $220 million) in 2011, which included city-generated funds, as well as state and national grants and loans.[31] The combined budget of KMDA and KMC for all planning, maintenance and infrastructural activities, not including police and fire services in 2011 was $637 million. To put this in perspective, New York City's sanitation budget alone in 2011 was $1.3 billion; this year more than twice the total budgets of the two agencies combined, over $1.34 billion, was allocated in its latest budget for reconstruction of the Brooklyn Bridge and the sanitation budget.

The challenges to adaptation are further intensified as substantial infrastructural deficits and resource pressures impair planning efforts. Increasing threats to the natural environment, pollution, overdevelopment, and unplanned, unregulated growth have also created extremely challenging conditions. Apart from these numerous constraints, when the coping capacities of these cities are also factored in--taking into account the size of their vulnerable populations, rising in both relative and absolute terms--the problem of adaptation becomes even more acute. Under such circumstances, planning for climate change is considered an added burden to the already taxed municipal governments. Given the additional

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[29] Information on New York City budget figures sourced from NYC budget statements 2011 and 2011. Retrieved from http://www.nyc.gov/html/omb/html/home/home.shtml accessed on 9/9/2012.

[30] Source: Kolkata Municipal Corporation, Meeting Transcript of Budget Statement for 2011-2012, by Mayor Sri Sonovan Chatterjee.

[31] Source: KMDA finances report 2011 Retrieved from http://www.kmdaonline.org/html/aar_2011.html.

resources and expertise required for comprehensive planning in this arena, adaptation is often not an option unless such efforts are externally motivated, funded, and managed.

DISSERTATION FOCUS

Given the ongoing and increasingly intensifying risks of climate change, aggravated by some of the primary challenges outlined previously, these cities cannot afford gestation periods to absorb a range of planning and policy experimentation in order to "get it right". It has never been more necessary to gain a critical understanding of effective climate adaptation strategies that are suitable in this context; the planning approaches adopted in these Asian mega-cities have far-reaching and permanent implications for the futures of not only the cities themselves but also for the entire South and East Asian region, which encompasses over 60% of the world's population.

The impetus of my dissertation stems from this urgent need to navigate this difficult landscape in South Asian mega-cities, where the need to find suitable climate-adaptation strategies is of paramount importance. The dissertation looks in depth at two broadly representative Asian coastal mega-cities, Dhaka, Bangladesh and Kolkata, India, in which the inherent problems, key indicators, and actual and potential policy measures are typical of many of the challenges that municipalities and populations across the Global South face.

How do cities in these regions plan to reduce their vulnerability and enhance their resilience in the face of a wide range of climate change risks, especially given the serious resource constraints I have mentioned? Are resource constraints an insurmountable barrier, or are there ways in which such challenges can be overcome? What are the implications of the dearth of formal climate-adaptation planning at the city level for the success of climate adaptation efforts? [32] These are some of the underpinning questions that serve to focus this dissertation.

In conducting field research on Kolkata and Dhaka—both resource-constrained cities, of which the latter faces the most severe resource constraints--I seek, both to understand the ways in which climate

[32] Although climate-adaptation planning in and of itself is no guarantee of actual adaptation, the lack of formal plans severely limits the potential for effective action (Preston, Westaway, and Yuen, 2011).

adaptation can succeed and to elucidate the strategic alternatives that have proven to be viable. My research design has also been constructed with the secondary intention of highlighting an extremely vexing puzzle, the solution to which has the possibility of shedding light on how some cities are better able than others, to navigate the primary obstacle of resource constraints. The two cases I have selected have been chosen strategically to illuminate the range of options that cities have in responding to climate change risks in the face of resources constraints. The analysis of these two cases presents a unique comparative opportunity. What are the factors in resource-constrained Asian mega-cities that account for the ability and propensity to initiate adaptation planning and implement risk management measures?

RESEARCH QUESTIONS

This research seeks to understand how vulnerability and resilience can be addressed within the context of ongoing investment in new development, improvements in infrastructure and basic urban services, implementation of environmental and related regulations, and emergency preparedness. I present an in-depth, cross-case analysis of how municipal governments of two coastal mega-cities of South Asia, Kolkata and Dhaka, are trying to adapt to climate change risk. More specifically, my research will seek to answer the following overarching question followed by a related sub-question:

In the face of existing resource constraints, what adaptation approaches have most effectively enabled these cities to respond to the risks related to climate change?

> *How have the local planning agencies overcome the various resource and institutional limitations inherent in planning activities in cities of South Asia to further such adaptation action?*

My research looks at a range of planning, development and regulatory activities in the two cities, primarily focusing on how the following barriers to adaptation-related planning activities can be overcome.

- *Resource Constraints* (principally financial and technical)

- *Institutional Limitations* (issues of coordination and implementation, institutional inertia, deficiencies in human and technical capacities, unclear jurisdictional responsibilities, overlapping reporting and accountability structures, and undue political pressures)

and

- *Enabling Support for adaptation-oriented planning* (political and stakeholder support, scope of project,)

The study focuses on these cities' responses to their most critical risks, particularly in flood management, water supply and quality and ecosystem management. The research will examine many factors including planning strategies, funding avenues, time frames, project oversight, and delegation of authority in evaluating the effectiveness of actual adaptation measures.

Dissertation Structure

In chapter two, *Water and Climate Change: Assessing Urban Risks,* I analyze the risks, vulnerabilities and Impacts from climate change and various anthropogenic factors such as population densities that exacerbate such effects. The aim is to understand how some of these climatic changes have far reaching effects on the entire region including Dhaka and Kolkata such as how glacier retreats affect overall water resources. In the following section of this chapter I narrow my focus to Kolkata and Dhaka where I analyze how non-climatic factors, the city topographies and geographical locations expand climatic impacts. Following this analysis I look at the common climatic changes that are occurring in both these cities including intense periods of rainfall, increasing risks due to magnified storm surges and cyclones, salinity intrusion and land subsidence.

The third chapter*, Evaluating Approaches to Adaptation in the context of South Asian mega-cities*, introduces the main theories of adaptation that are pertinent to the scope of this research. The chapter begins with a discussion on the emerging importance of adaptation and provides a working definition of how adaptation is viewed in the context of this definition. Following this introductory section, I discuss the different types of adaptation such as "planned and "autonomous" that have gained traction in the adaptation literature. For the last section of this chapter, I introduce a selected range of adaptation theories most directly associated with my work. In highlighting these theories, I provide a detailed discussion of these approaches as presented in the literature followed by an analytical section for each which evaluates the potential relevance of these options in the context of South Asian cities. The principal theoretical strains that I examine include, the "no regrets approach" and "transformational adaptation", "Adaptation as Development" which comprises a discussion of the "Vulnerability Reductions" and "Adaptation" approaches and finally the integration of Adaptation with Disaster Management, and Mitigation.

Of all these approaches evaluated in this chapter, the no-regrets approach provides the most applicable framework from which to draw on, in the context of South Asia. This approach focuses on finding climate-adaptation "actions that generate net social benefits under all future scenarios of climate change and impacts" (Heltberg, Siegel, and Jorgensen, 2009: 89). Such approaches should likewise "allow cities to simultaneously reduce vulnerability, enhance resilience, save money in the near term and create new revenue streams over time" (Susskind, 2010: 220). This view emphasizes the identification and use of measures that reduce vulnerability and increase resilience while advancing development and alleviating poverty.

Chapter four, *State of Adaptation in Dhaka and Kolkata*, includes a survey of adaptation efforts currently underway in South Asian cities. This "survey" looks at the types, scale, duration, and effectiveness of these adaptation efforts in addition to the institutional drivers, resources, and other factors that have made this possible. Then, I examine the current state of flooding and drainage congestion in Kolkata and Dhaka to provide a brief analysis of the factors promoting or hindering climate adaptation in these areas. Following this, I describe the adaptation efforts underway in Kolkata and Dhaka, including the planning efforts that can directly be linked to climate adaptation and resilience. I also discuss three cases of failed adaptation efforts in the two cities, in order to understand the factors that hinder effective reduction of climate risks.

Chapter five, *Mainstreaming Adaptation in the Water Sector: Lessons from South Asian mega-cities*, contains the principal findings from my fieldwork. In this chapter, I look at different projects in Kolkata and Dhaka, drawing primarily upon data collected through extensive field interviews and observation. I analyze three successful projects that have been undertaken across these cities to address issues of flood management, urban wetlands management and water supply and quality. I identify the successful aspects of these projects in these fields to determine approaches that can be utilized to further climate-change adaptation. The last section of the chapter discusses the larger implications on theory and practice that are gleaned from these analyses.

Chapter six, the conclusion, addresses three interrelated issues. First, I explain why South Asian mega-cities represent a crucial focus for climate adaptation. The particular vulnerabilities this region will experience make cities like Kolkata and Dhaka ideal sites for climate-change action. Second the chapter then considers possible pathways to adaptation in South Asia, centering on two theoretical perspectives—adaptation as development ("no-regrets") and developmental adaptation in the framework of institutions. Finally, this chapter proposes an integrative adaptation-approach, which contains both developmental, and adaptation benefits, tailored to the specific context of resourced-constrained mega-cities of the Global South. The chapter concludes with two smaller sections, which elaborate on the contributions of the overall research and expand on the limitations and future direction of this work.

RESEARCH DESIGN

Case Selection

The climate-related risks now experienced by cities in Asia are already evident in the sea-level rise, altered rainfall patterns, substantial increases in average temperatures, and mounting frequency and intensity of environmental catastrophes in this region. That most of the Indian subcontinent's metropolises[33] are located in highly vulnerable coastal or delta regions further heightens the risks for not only the physical and human environment, but also for regional and global political and economic stability, food production, and natural resources. The two mega-cities central to this study, Dhaka and Kolkata, clearly exemplify these types of susceptibility. The cross-case analysis of these two coastal cities, in two bellwether countries of the region, offers some important control variables regarding the nature of climatic threats, and institutional and political structures. At the same time, the cities' differing political environments, municipal institutional organizations, climate-awareness levels, and resource capacities account for important differences, thereby

[33] Aside from Dhaka and Kolkata, Mumbai, Karachi, Colombo, and Chennai are also large coastal cities at great risk of climate-related disaster.

offering significant opportunities for a comparative study of climate-adaptation efforts. Moreover, an in-depth examination of these factors makes the two cities valuable cases for testing the effectiveness of planning and policy decisions for a broader cross-section of resource-constrained large cities in developing regions, which are likewise gravely threatened by the impacts of climate change.

Both Dhaka and Kolkata are located in the world's largest mega-delta, which the IPCC (International Panel for Climate Change) and others have identified as that most at-risk for the impacts of climate change. These risks manifest themselves in many areas, such as rapid, above-average rates of sea-level rise, periods of intense rainfall, cyclonic activity, excessive rainwater runoff, reduced sedimentation caused by upstream dams and coastal erosion, considerable subsidence, and salt-water intrusion. Moreover, issues concerning water resources, urban flooding, and depletion of wetland systems remain pressing problems.

Both cities also face many of the same challenges in designing and implementing effective adaptation strategies. The rapid rate of urbanization—intensified by the influx of climate refugees and the relative economic opportunities offered by both urban centers—and the need to provide basic services while preparing for exposure to extreme climatic threats, including cyclones and flooding, remain difficult challenges. Dhaka is projected to reach a population of 25 million within the next fifteen years, principally through in-migration from surrounding rural areas. Located on the Buriganga River in the low-lying Ganges-Brahmaputra Delta, Dhaka is the world's most densely populated major city and one of the poorest, with a current per-capita annual income of just $500 (World Bank, Databank, 2012). Its poverty, location, poor infrastructure, and high population density render it highly vulnerable to disease and climate-related disasters. Kolkata, the former political and cultural capital of India and current capital of the state of West Bengal, likewise lies on the Ganges-Brahmaputra plain, on the Hooghly River, and faces many of the same challenges regarding density, poverty and poor infrastructure. Kolkata, however, is a much wealthier city, with a per-capita income of just over $5000, ten times that of Dhaka.

Kolkata and Dhaka possess roughly similar demarcations of local and national responsibility for addressing climate-change and Disaster Risk Reduction (DRR) issues. While both Kolkata and Dhaka are capitals of the state of West Bengal and the Dhaka Division, respectively, Dhaka is also the national capital; national policies and initiatives thus most directly influence Dhaka, whereas Kolkata's initiatives are supported more at the state level. In practice, though, neither of the state governments plays an important role in climate adaptation in the two cities.

The selection of these two cities is based on the criteria that Dhaka and Kolkata share not only history and elements of culture, but also planning structures and paradigms; overlapping, multi-agency governance for climate adaptation; institutional configurations; and the specific nature of the climatic threats each faces. However, despite these markedly similar characteristics, the differences in their respective resource levels, adaptation approaches, and comparative levels of success in responding to climate change make for an interesting comparison. The fact that Dhaka shows a higher level of awareness and adoption of climate adaptation measures, despite its shortfalls in the aforementioned criteria, makes for a robust research project, one that allows for the isolation of key variables that affect adaptation outcomes.

Methodology

The findings presented in this dissertation draw on an in-depth understanding of the nature of adaptation-oriented strategies that have been adopted in Dhaka and Kolkata by municipal agencies. However, my investigation also encompasses national- and state-level adaptation planning efforts, institutional arrangements, and the actions of private entities, such as environmental professionals and activists, to the extent that they influence city-level decisions and outcomes.

In each of the two cities, I examine the nature and effectiveness of implementation of adaptation-oriented planning while accounting for a number of factors, including institutional responses and the roles of various stakeholders. Since both cities lack formal city-level adaptation plans, the cases chosen to elicit the nature and types of adaptation fall under the larger umbrella of infrastructure and "development" plans for the cities; both rely primarily on such measures to increase resilience and decrease overall vulnerabilities, many of which are directly or indirectly related to climate change. The study of these developmental planning endeavors that address climate-change risk enables the examination of the types and nature of adaptation efforts in the larger "planning" context. This research in turn offers an invaluable perspective for determining the policy and planning measures that can actually be effective, scalable, and generalizable as "adaptation" approaches, particularly within resource-constrained environments.

Two critical sectors for adaptation, water and eco-systems, serve as the analytical focus for this research; the challenges in these sectors are common to many major cities throughout the South Asian region. I have selected three specific areas that relate most directly to adaption to climate change and for which one or both cities have taken significant action:

- Urban flood management
- Urban wetlands/environmental protection and management
- Water supply and quality

My research focuses on ongoing planning projects that have the potential to reduce vulnerability and increase resilience to climate change. This work evaluates adaptation efforts by analyzing the responses to, and structural and policy changes arising from, the aforementioned climate risks in these two cities that are directly related to water and wetland resource management. In evaluating the effectiveness of these strategies, I have generated a series of indicators for project evaluation that are based on the following evaluative criteria.

1. Does the project address any local climate risks?
2. Does the project tackle any planning, developmental, or infrastructural objectives?
3. Were explicit policies or planning measures to deal with these climate risks already in place before the project commenced?
4. Were the climate risks assessed prior to the implementation of the project?
5. Were new measures integrated into existing projects to manage climate risks?
6. Are there any specific metrics or standards for the success of the project?
7. Does the project display any synergies among the involved sectors?
8. Did the project convey any social benefits or lead to relevant innovations?

Data Collection and Analysis

The research was conducted in four phases. The first phase entailed documentary analysis of climate-action, development, and infrastructure plans, related policy documents, and various contemporary media sources to analyze the preexisting climate-related strategies and plans for the two cities. The initial analysis provided a resource baseline for the second phase of the research, which consisted of the first round of field interviews[34] with technical experts, policymakers, planners, municipal decision makers, academics, and other organizational representatives involved in climate planning for the two cities. After the first round of interviews, I conducted additional archival research and analysis of the field interviews and documents procured during my fieldwork. In the third phase, I returned to Dhaka and Kolkata for my second round of field interviews,[35] during which I interviewed additional experts and conducted follow-up meetings with many of those whom I had interviewed in the first round. The fourth phase consisted of final analysis of all the data gathered (in the form of both interviews and documents) as well as additional secondary research to shape the ultimate conclusions of the research.

This scholarship utilizes multiple sources of complementary data, in the form of documentary analysis and interviews, to provide higher validity by enabling triangulation of the research results, facilitating identification of interviewee biases, and filling gaps in the data.

Field Interviews

Prior to both field trips, I scheduled a number of face-to-face interviews by mail and e-mail, with telephone confirmation wherever possible. The actual interviews for both rounds (of a total of 96), were preceded by some background interviews, prior to arriving in India and Bangladesh, with key subjects with whom I had already established a professional rapport. The background interviews provided "expert" information for the study, helped to identify local planners for subsequent in-depth interviews, and assisted in locating and procuring policy and planning documents relevant to the

[34] The first round of field interviews were conducted in December 2010 and January 2011 in Dhaka and Kolkata.

[35] The second round of the field interviews was conducted in May and June 2012.

study. These background conversations were followed by subsequent in-depth interviews with city- and state-level planners and other pertinent stakeholders during both visits. A detailed list of all the agencies of both cities represented through the interviews, along with the names and positions of selected interviewees,[36] can be found in Appendix 1.

These interviewees were identified and selected through information available on relevant agency websites, referrals from key informants, and subsequent snowball sampling—both to increase the probability of finding interviewees within the target population of the local planners and to leverage network connections and thus obtain greater cooperation. Over the course of two field trips, I conducted 96 unique interviews; I also carried out follow-up interviews with several of the subjects in each city. By conducting in-depth interviews of senior and mid-level officials at the central, state, and local levels, representatives of donor agencies, and a few private actors, I was able to develop a more nuanced understanding of the issues and corroborate the interviewees' responses across the interviews, thereby reducing errors in data resulting from interviewee biases.

All the in-depth interviews consisted of a semi-structured format to keep the responses focused on areas pertinent to the study. Though the initial interview questions had a cross-sectional consistency to provide relative standardization in the responses, the follow-up open-ended questions asked accounted for the variations among the professional roles, nature of information that they possessed and particular areas of expertise of the interviewees. The interviews were conducted in both Bengali and English, as per the preference of the interview subject.

Analysis of Plans

A "plan coding" technique, adapted from the frameworks discussed below, was used to analyze the available master and development plans and Disaster Risk Management (DRM) plans of the two cities, in order to gauge the extent to which the master plans take account of climate vulnerability. The "plan coding" technique was adapted from the Dalton and Burby (1994) model, and the "design coding" process used by CABE (CABE Report, 2002). Dalton and Burby's generative model proposes an

[36] The names and positions of some of the interviewees will not appear in the appendix, as they wished to remain anonymous. However, the agencies that these anonymous interviewees represent are listed.

analytical framework by which to examine the linkage between the local plan quality and planners' consideration of factors such as state mandates and political actions, resources, population density, and past hazard experience. The authors also consider the milieu in which government operates, influenced by political demands, supports, and environmental characteristics (Dalton and Burby, 1994). The "Design Coding" process developed by CABE provides a qualitative framework for testing the sustainability of master plans against mandated urban design codes for a particular district.

Documentary Analysis

The policy documents pertaining to Kolkata and Dhaka, some of which were assumed to cover a wide range of issues within a single document, were analyzed using "content analysis", a method similar to that proposed by Holsti (1969). The content analysis specifically focused on only those parts of the policy documents that pertained to climate-related risks and adaptations in the two sectors investigated in these case studies. To conduct the documentary analysis, *content categories* were defined according to the evaluative criteria noted earlier. Moreover, since these content categories correspond to the "response categories" in the semi-structured interview instrument, this approach facilitated comparison among the results of the interviews and policy documents during the analysis of the composite research results.

A grounded theory approach, as proposed by Glaser and Strauss (1967) and Strauss & Corbin (1990), was used to analyze the full data set. This approach is best suited for exploratory research and is generally employed as a strategy for comparative analyses, as in the case of this dissertation. The organized data from the interviews, plan coding, and content analysis were coded into *conceptual categories* that corresponded to the two sectors, water and eco-systems, selected for this study.

The categories within each group, as well as across the two comparison groups, were analyzed to understand the intrinsic relationships among the policies, planning decisions, and adaptation approaches in these two cities. Lastly, the findings across the categories of the two comparison groups were evaluated through an iterative process to explain the three main objectives that guide the proposed research:

1. To identify the approaches that best facilitate effective adaptation at the city level in South Asia.

2. To understand the strategies that best enable more efficient resource allocation, overcoming of institutional limitations, and broad support for such adaptation actions.

3. To explore a theoretical foundation to inform successful local climate-adaptation planning under conditions of resource constraints.

This study thus draws upon complementary sources of information, analytical approaches, and research methods to create a rich interpretive framework for comprehending climate-change adaptation in South Asian mega-cities. This research should moreover provide practical guidance to planners, governmental authorities, and private actors for fruitful policy direction in responding to climate change.

2

WATER AND CLIMATE CHANGE: ASSESSING URBAN RISKS

Exposure to life-threatening climate risk in large cities across the world is expected to double by 2050, affecting 1.5 billion people, versus an estimated 680 million in 2000. The most acute of these climate impacts will be earthquakes and cyclones (GFDRR, 2010). Urban centers in Sub-Saharan Africa, East Asia, Latin America and the Caribbean will be the most vulnerable; however, the fastest exposure growth rate (of 3.5 percent) and greatest threats will be experienced in South Asian mega-cities, particularly in the increase and intensity of cyclonic events (Dickson, Baker, Hoornweg, Asmita, 2012).

Given the critical, escalating nature of these climatic threats, an assessment of urban climate risk is essential for cities to identify areas that urgently require attention. Moreover, the cumulative effects of rapid urban expansion and climate variability on an already vulnerable population impose additional challenges to effective urban management and delivery of key services. Since these risks have grave implications for South Asian mega-cities, this chapter aims to provide an understanding of these factors—key background information on the types of climate risks that need urgent adaptation--and ultimately to answer the primary research question that guides this dissertation:

> *In the face of existing resource constraints, what planning approaches and other factors have most effectively enabled these cities to adapt to risks related to climate change?*

The first section of this chapter comprises a broad discussion of the vulnerabilities and impacts in South Asian cities, including not only the acute climate risks facing South Asia but also several other anthropogenic factors (including population growth, acute poverty, and poor infrastructure) that exacerbate the situation. The second section narrows the area of investigation to focus on the two cases selected for the dissertation, Kolkata and Dhaka. This section provides a brief introduction of the geography and demographics of each city followed by a brief risk-assessment summary to shed light on the sectors that face the highest risk and that therefore require urgent adaptive interventions.

RISKS, VULNERABILITIES AND IMPACTS IN SOUTH ASIAN CITIES

Cities in the developing world are facing increased risk of disasters and the potential of economic and human losses from natural hazards is being exacerbated by the rate of unplanned urban expansion and influenced by the quality of urban management. Climate change brings additional challenges with a growing number and variety of impacts on cities, their critical ecosystems and citizens' livelihoods (Dickson, Baker, Hoornweg, Asmita, 2012).

Introduction

According to the research findings presented in a 2008 World Bank report titled "Climate Resilient Cities", Asian mega-cities are now considered the "hotspots" for climate risk. The acute vulnerability of this region can be attributed to a range of factors whose mutually reinforcing effects amalgamate to create "mega regions of mega-stress". Three primary factors contribute to this situation. First, *climate risks*, which include variability and hazards, increase the measure of vulnerability in the short term. Such risks include an increase in the frequency of climate hazards, such as cyclonic storms and flooding, as well as more frequent and intense periods of rainfall outside of the regular monsoon seasons. In the longer term, these climate risks may bring about irreversible systemic degradation, including sea-level rise and saline water-intrusion. Second, the *large population densities* of these cities mean that the potential loss of life and infrastructure damage increases exponentially during serious climate events. Lastly, *socio-economic conditions* further intensify the stress generated by these climate risks; the large concentrations of poverty among urban dwellers of South Asian cities further reduces their capacity to cope with the added effects of climate change.

Climate Change in the Water Sector

Bounded in the north by the Himalayan ecosystem, South Asia's geographical location contributes significantly to the vulnerability of the region. This eco-system, which currently supports over 1.5 billion people, remains essential to the region's sustenance for a number of reasons. Not only does it represent the principal water source of Asia's largest rivers[1], but it also provides groundwater recharge and creates large alluvial floodplains for crops. Additionally, the ecosystem regulates the dynamics

[1] These include the Ganges, Indus, Bramhaputra, Yangtze, Mekong, Salween and Yellow Rivers. By 2035, these rivers might dwindle or even disappear because of rising temperatures and other related factors (IPCC, 2007).

of South Asia's monsoons, which are critical to food production, among other allied benefits. Thus the system's continued protection remains vital for the region. In South Asia, the effects of climate change will be experienced most strongly in the perturbations of the water sector. These changes will likely manifest in a number of climate risks; its most direct and immediate effects will come in fundamental areas such as *fresh water supply*, *food security*, and *eco-systems* (particularly wetlands and coastal mangrove barriers). In addition, *climate disasters* such as cyclones, storm surges and floods have also increased in frequency and intensity because of climate change.[2]

A recent study (*Mega Stress for Mega-Cities*, commissioned by the World Wildlife Foundation) evaluated climate risk for eleven key coastal mega-cities of South Asia.[3] Overall, Dhaka was ranked the most vulnerable, while Kolkata was ranked fourth. The study points to dramatic increases in sea levels and greater intensity and frequency of flooding and storm surges as the key concerns for Dhaka. The projected one-meter rise in sea level means that Bangladesh would lose approximately 1,000 km^2 of cultivated land and much of its aquaculture. Exacerbating the effects of sea-level rise, Bangladesh sits only meters above current sea levels; Dhaka is sinking due to subsidence, estimated at 0.6 to 1.9 mm. annually. IPCC projects that the combination of rising seas and subsidence will result in salt-water intrusion of up to 100 km from the coast, impacting millions of people. Salt-water intrusion will impact the availability and quality of freshwater and rice production, a huge source of food for the region. In fact, production of rice and wheat are projected to drop by 8% and 32%, respectively, by midcentury, due to climate change.

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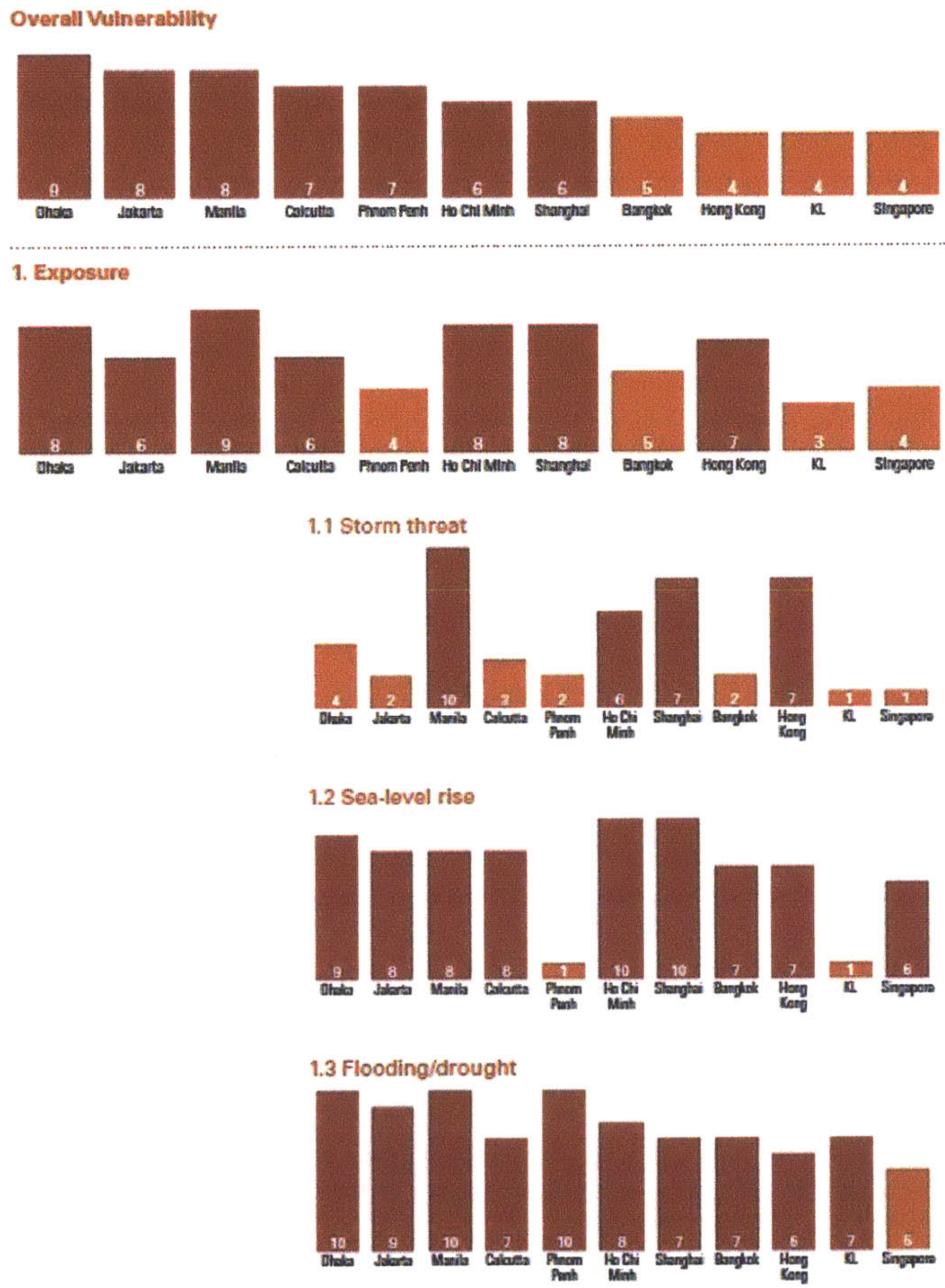
[2] Storm surges and cyclonic activity most severely affect areas such as Bangladesh and the Indian State of Orissa, while rising sea levels and littoral storms present the greatest dangers for low-lying territories and islands, including the Maldives, Sri Lanka, and parts of Bangladesh.

[3] The 11 key coastal mega cities investigated in the report were Dhaka, Jakarta, Manila, Kolkata, Phnom Penh, Ho Chi Minh City, Shanghai, Bangkok, Hong Kong, Kuala Lumpur, and Singapore.

FIGURE 2.1: Vulnerability, Exposure and Climate Risk rankings for 11 South Asian mega-Cities
Source: WWF, 2009



Kolkata is expected to face many of the same serious, escalating risks confronting Dhaka—sea-level rise, flooding, and storm surges—resulting from a changing climate. Many areas of the city and surrounding region are expected to become uninhabitable; over 5700 km^2 of land would be lost with a one-meter rise in sea levels. Kolkata is facing similar levels of subsidence activity (0.6 to 1.9mm annually) and saltwater intrusion (up to 100km from the coast). However, Kolkata's overuse of groundwater—primarily through the use of bore-wells—adds an extra dimension to the city's challenges. This overuse not only causes further saltwater intrusion, but also increases the salinity of subsurface water.

The *Mega Stress for Mega-Cities* study also found that in cities like Dhaka, tropical cyclones and flooding will be more of a common occurrence, while Jakarta and Manila[4] were mainly susceptible to flooding. Sea-level rise is considered a "real" threat in Shanghai and Ho Chi Minh City; Kolkata, located in the Indo-Gangetic Plain amidst riverine systems, is threatened by both sea-level rise and salt-water intrusion. The report also found that, though the quantity and intensity of environmental events would certainly vary among the eleven cities, each would experience debilitating climatic and weather occurrences, including sea-level rise of at least one meter; two-meter storm surges; more numerous and acute episodes of drought and inundation; and stronger, more frequent cyclonic activity.

Climate change will most directly cause *rises in temperature,* whose fluctuations will be felt in *changing precipitation trends* and will increase *glacial retreat, sea levels,* and *surface-water runoff.* This section provides a brief descriptive summary of the some of the major regional and global effects of climate change, followed by an assessment of how these impacts translate into climate risks in the specific context South Asia.

Increases in temperature

Some studies project a rise in average annual temperature of as much as 2.4-4.5 degrees Celsius by the end of the century[5], with the greatest rises

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[4] Typhoon Ketsana, which struck the Philippines in 2009, highlighted the risks faced by the mega-city of Manila; floodwaters approached seven meters and nearly 500 people were killed in this single weather event.

[5] Global temperature rise is caused principally by carbon emissions in the atmosphere, which prevent the Sun's heat from radiating back into space—the so-called "greenhouse

between December and February (Islam, Hove, Parry, 2011). Even in the IPCC's lowest future emissions scenario (Cruz, et. al., 2007)[6], overall temperatures will increase by 1-2°C (~2-4°F) in South Asia, during the historically cooler months of December, January and February. By the 2080s, the increase is projected at almost 3°C (5.5°F). The highest emissions trajectory, which assumes only limited global mitigation and population efforts, predicts mean temperature increases of over 3°C by the 2050s and 5°C (9°F) by the 2080s (See Table 2.1).

TABLE 2.1: Projected changes in surface air temperature and precipitation for South Asia "under SRES A1F1 (highest future emissions trajectory and B1 (lowest future emissions trajectory) pathways for three time slices, namely 2020s, 2050s and 2080s".

Source: Table excerpted from Cruz, et. al., 2007

Season	2010 to 2039				2040 to 2069				2070 to 2099			
	Temperature °C		Precipitation %		Temperature °C		Precipitation %		Temperature °C		Precipitation %	
	A1F1	B1	A1F1	B1	A1F1	B1	A1F1	B1	A1F1	B1	A1F1	B1
DJF	1.17	1.11	-3	4	3.16	1.97	0	0	5.44	2.93	-16	-6
MAM	1.18	1.07	7	8	2.97	1.81	26	26	5.22	2.71	31	20
JJA	0.54	0.55	5	7	1.71	0.88	13	11	3.14	1.56	26	15
SON	0.78	0.83	1	3	2.41	1.49	8	6	4.19	2.17	26	10

In this scenario, the warmest low-lying areas, such as the Maldives and Sri Lanka, will likely experience a temperature rise of about 1°C, whereas temperatures in countries, such as Bhutan, Nepal and Afghanistan, located in higher altitudes will rise by about 1.5-2.5°C. Research also shows that, in the last century, temperatures in Asia have already increased by 1-3°C (WWF, 2009).

effect". Emissions in developing countries are expected to rise at an annual rate of 2.7% until 2025 and to surpass those of developed nations by 2018 (Sarkar 2011)

[6] The moderate scenario of the IPCC climate projections includes some of the following assumptions: low population growth rate; moderate land-use changes; high GDP; high technological change; and medium availability of oil and natural gas resources. (Nakicenovic and Swart, 2000)

Glacial retreats

Glacier retreats are considered sensitive to "high indicators" of climate change[7] (Gurung and Bajracharya 2012; Armstrong 2010; Zemp and Van Woerden 2008). Rising temperatures from primarily from greenhouse gas emissions are leading to glacial retreats, which have hastened the degeneration of the Himalayan eco-system and engendered wide-ranging negative consequences for the region. Between 1975 and 2005, for the Himalayan system in the Nepal region, glacier retreat has correlated directly with the rise in average temperature, which has been at the rate of 0.04°C per year—and even greater at the higher altitudes (Baidya, Regmi and Shrestha, 2007; Gurung and Bajracharya 2012). Similarly, several other studies have found indication of glacier retreats in this region in the past two decades (Fujita et. al., 1997, 2001; Kadota et. al., 1997, 2000; Ageta et. al., 2001; Naithani et. al., 2001) increased temperatures, decreased precipitation and changes in humidity have been responsible for the glacial recessions (Vohra, 2010; Kaser and Noggler, 1991; Hastenrath and Kruss, 1992; Kaser, Georges, and Ames, 1996; Kaser and Georges, 1997; Kaser, 1999; Wagnon et. al., 1999). The Himalayan glaciers are shrinking faster than any others worldwide. At present rates, the glaciers could disappear by 2035; more optimistic projections show an 80% drop in total area (from 500,000 to 100,000km^2) over the next twenty-five years (WWF, 2005).

TABLE 2.2: Record of some glacier retreats in the Indian Himalayan region that affect the Indo-Gangetic plains where Dhaka and Kolkata are located
Source: Cruz et. al., 2007

Glacier	Period	Retreat of Snout (metre)	Average Retreat of Glacier
Trilokhnath Glacier (Himachal Pradesh)	1969 to 1995	400	15.4
Pindari Glacier (Uttaranchal)	1845 to 1966	2,480	135.2
Milam Glacier (Uttaranchal)	1909 to 1984	990	13.2
Ponting Glacier (Uttaranchal)	1906 to 1957	262	5.1
Chota Shigri Glacier (Himachal Pradesh)	1986 to 1995	60	6.7
Bara Shigri Glacier (Himachal Pradesh)	1977 to 1995	650	36.1

[7] Since 1850AD (at the end of the Little Ice Age), Himalayan glacial retreats with corresponding increase in temperatures have been evident (Mayewski and Jeschke 1979; Gurung and Bajracharya 2012: 267; Sharma et., al., 2009).

Gangotri Glacier (Uttaranchal)	1977 to 1990	364	28.0
Gangotri Glacier (Uttaranchal)	1985 to 2001	368	23.0
Zemu Glacier (Sikkim)	1977 to 1984	194	27.7

It is difficult to overestimate the significance of the Himalayan glaciers for the Indian subcontinent. The Himalayan glaciers cover 27% of the range's area (by way of comparison, the Swiss Alps have only 2.2% glacier area) and contain about 12,000km^3 (or over 3 trillion gallons) of fresh water, about the same as Lake Superior. These glaciers currently hold about 12% of the planet's freshwater supply. The Himalayan snow and glacier melts supply most of the freshwater river flow in the entire Indian subcontinent and are the source of its three largest rivers (the Indus, Ganges, and Brahmaputra). At projected levels of decline, these rivers (and of course their numerous tributaries and streams) could become merely seasonal water bodies, causing localized drought and desert conditions, threatening widespread famines, and displacing tens or hundreds of millions. Recognizing Himalayan glaciers as crucial water reserves and effectively managing them could help avoid a medium-term environmental catastrophe.

Precipitation Trends

While there are some conflicting views regarding the precipitation trends in South Asia (some researchers view the core precipitation trends as stable)[8], the *World Bank Climate Report* (The Regional Scene) reflect the consensus on this issue: "The wet regions will get wetter while the dry regions will get drier." Climate change will thus worsen water conditions throughout the Subcontinent, with severe flooding and agricultural inundation in the deltas of the South and East and droughts and desertification in the North and West. These IPCC projections suggest that changing precipitation trends will likely increase the duration and intensity of both floods and droughts in South Asia though the report acknowledges some discrepancies in these projections, especially in the forecast of northwest India (Cruz et. al., 2007). These climatic events are particularly

[8] A 2004 report by the Ministry of Environment and Forests (MOEF), Government of India, dismisses the general IPCC findings in this regard, as the Ministry's calculations show a stable core with no discernable changes in precipitation trends other than the high seasonal variations, which have historically been part of monsoon patterns. The conclusions of the MOEF, however, differ from those of most other researchers.

difficult to predict, as weather patterns in neighboring regions can cause monsoon intensity to vary greatly (Webster and Yang, 1992; Wang and Fan, 1999), which creates added uncertainty in managing such changes. Overall, precipitation is likely to increase by 4% under lowest emissions scenarios in the 2020s and then decrease by 6% in the 2080s during the historically cooler months of December, January and February. Under the highest emissions trajectories, during these months, there will be a decrease of 3% in the 2020s, which will stabilize in the 2050s and eventually decrease greatly (by 16% as of the 2080s). Thus, precipitation levels and intensity will tend to extremes both by region and by season (See table 2.1). The implications for agriculture, water security, and climate adaptation in South Asia are therefore enormous.

Water Runoffs

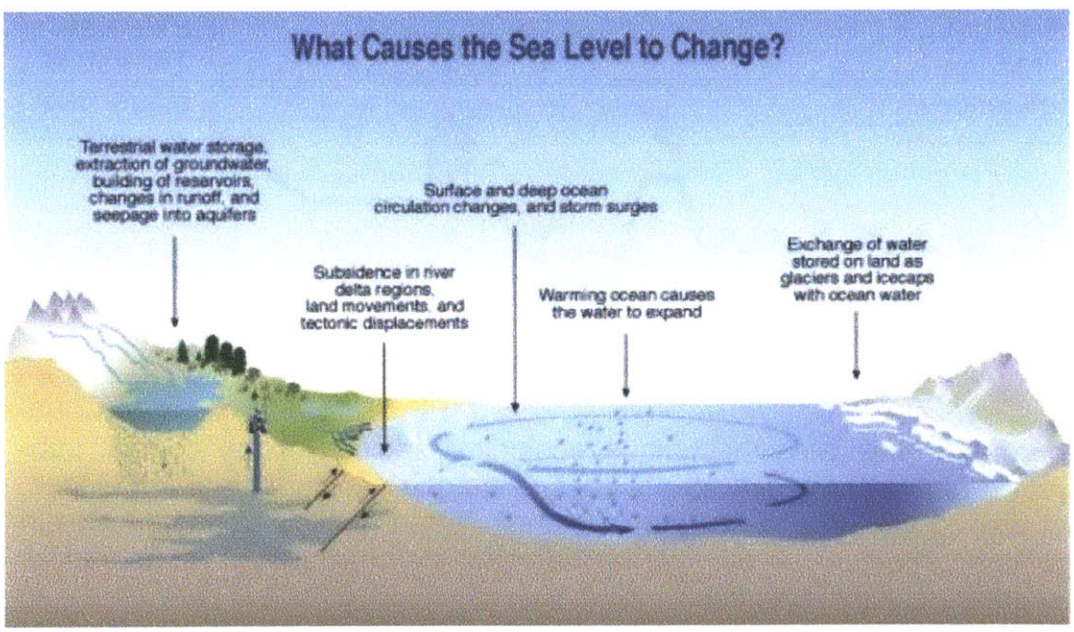
The changes in precipitation trends and temperatures in South Asia also disturb the balance of the "green-" and "blue-water" runoffs. The term "green water" refers to the portion of rainfall that is absorbed into the Earth and enables the growth of both wild flora and crops, while precipitation that runs off, directly or after drainage, into surface bodies such as rivers and streams is termed "blue water". Green water, which depends in large measure on the absorbent capacity of soil, is the planet's largest fresh-water source and thus represents a crucial indicator of ecological sustainability. Additionally, these changes also contribute to mean sea-level rise through complex and interdependent processes. According to IPCC projections, under a high-emissions scenario the annual run-off in South Asia will increase by 20-30% by 2050 (relative to 1900-70), which will have a direct effect on recharge of water bodies and ground water.

Sea-Level Rise

Rise in sea levels are projected at a mean of 0.4 meters in the South Asian region by the end of the century, if glacial melts remain constant (IPCC Fourth Assessment). Overall sea-level rise in coastal Asia ranges from one to three millimeters annually, slightly higher than the global average, but evidence suggests that even this figure understates the current trend (Dyurgerov and Meier, 2000; Nerem and Mitchum, 2001; Antonov, Levitus and Boyer, 2002; Rignot, Rivera, and Casassa, 2003; Woodworth, Gregory and Nicholls, 2004). Arendt et al. have found an increase of 3.1mm/yr over the past decade, versus 1.7- 2.4mm for the century as a whole (Arendt et al. 2002; Rignot et al. 2003), which suggests that the sea-level rise has accelerated relative to the long-term average (Cruz et. al., 2007).

Apart from the increase in "blue water" runoffs, several other factors contribute to sea-level rise as well. Increased glacial melts, subsidence in delta regions of rivers, tectonic displacements, and general ocean warming (which results in water expansion) increase ocean volume (see figure 1). Worst case-scenarios predict an "existential threat", (the kind of risk that can potentially lead to extinction) for many of the small island nations (e.g., the Maldives), and low-lying coastal areas of South Asia, when accounting for their present adaptive capacity. In non-island nations such as Bangladesh—one of the world's most vulnerable nations—sea-level rise of up to 1.5 meters is expected by 2050, causing the destruction of a large part of its coastline (Broadus, 1993).

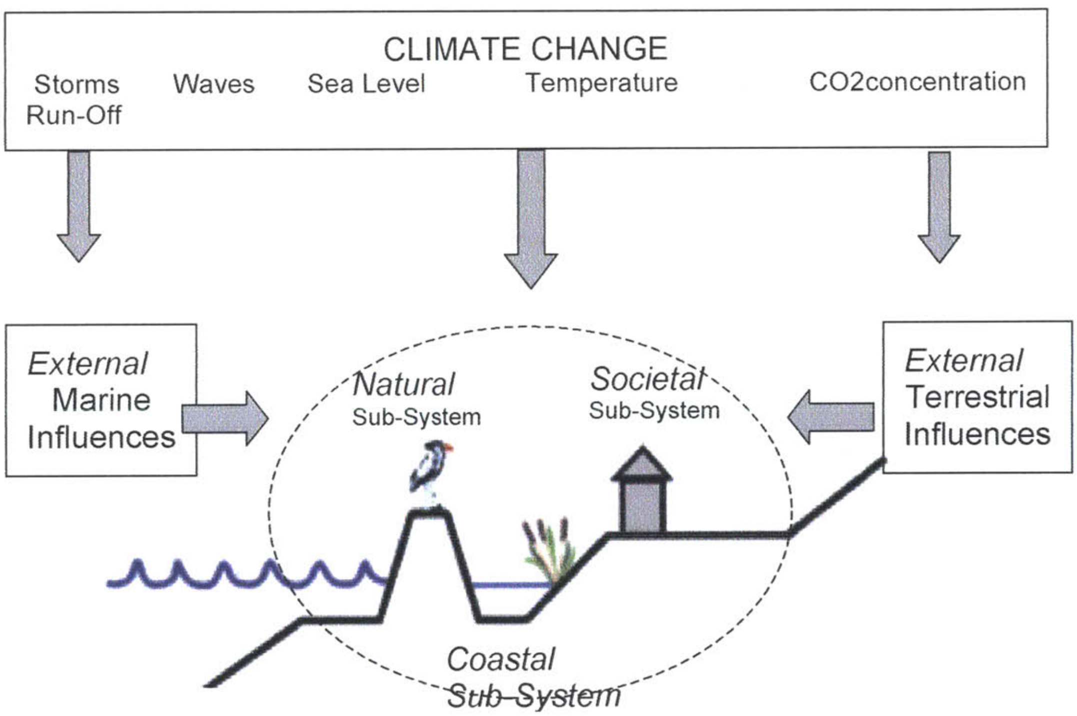
FIGURE 2.2: Factors contributing to Sea-Level Rise
Source: Griggs, 2001



Climate Risks

In South Asia, these interrelated effects of climate change interact with existing socio-ecological networks to create a number of climatic risks (see figure 2.3).

FIGURE 2.3: Climate Change and the Coastal System showing major climate-change factors, including external Marine and Terrestrial Influences.
Source: Figure adapted from IPCC 2007, WWF Report, 2009.



This figure illustrates the unique ecological position of the coastal sub-system, subject not only to contrasting marine and terrestrial influences, but also to natural and societal stresses. When multiple impacts move in the same direction, as with global warming, the coastal subsystem suffers the greatest consequences.

As mentioned earlier, these risks arising from water-related climate change will likely have direct consequences in fundamental areas such as *fresh water supply*, *food security*, and *eco*-systems and engender *extreme climate events.* A range of other factors, including resource constraints and weak institutional capacities, further intensify these risks. Rapid urbanization, overpopulation and rampant poverty also aggravate these risks. According to a 2009 World Bank Report, by 2050, South Asia will be home to more than 2 billion people, most of whom will be residing in metropolitan areas; 40% of South Asians—600 million people—survive on less than $1.25/day. All these factors contribute significantly to the vulnerability of the region.

According to IPPC 2007, as compared to other regions of Asia, South Asia is *highly vulnerable* to all the risks associated with climate change in the region (except settlements). South Asia is thus, across the board, at greatest risk in the continent, with the highest levels of confidence and ratings in the categories of *Food and Fibre, Biodiversity, Water Resource,* and *Coastal Ecosystem* vulnerability (See table 2.3). The region's large population and sobering risk levels should make South Asia a center of climate research and of climate-adaptation planning.

TABLE 2.3: Vulnerability of key sectors to the impacts of climate change by sub-regions in Asia Source: Table excerpted from IPCC, 2007

Sub-regions	**Food and Fibre**	**Biodiversity**	**Water resource**	**Coastal ecosystem**	**Human health**	**Settlements**	**Land degradation**
North Asia	+1/H	-2/M	+1/M	-1/M	-1/M	-1/M	-1/M
Central Asia and West Asia	-2/H	-1/M	-2/VH	-1/L	-2/M	-1/M	-2/H
Tibetan Plateau	+1/L	-2/M	-1/M				-1/L
East Asia	-2/VH	-2/H	-2/H	-2/H	-1/H	-1/H	-2/H
South Asia	-2/H	-2/H	-2/H	-2/H	-2/M	-1/M	-2/H
South-East Asia	-2/H	-2/H		-2/H	-2/H	-1/M	-2/H

Vulnerability
-2 Highly Vulnerable **-1** Moderately vulnerable **0** Slightly or not vulnerable

+1 Moderately Resilient **+2** Most Resilient

Level of Confidence
VH Very high **H** High **M** Medium **L** Low **VL** Very low

FIGURE 2.4a: Availability of water resources per capita by world, region and sub-region, 2008
Source: UNESCAP, 2011

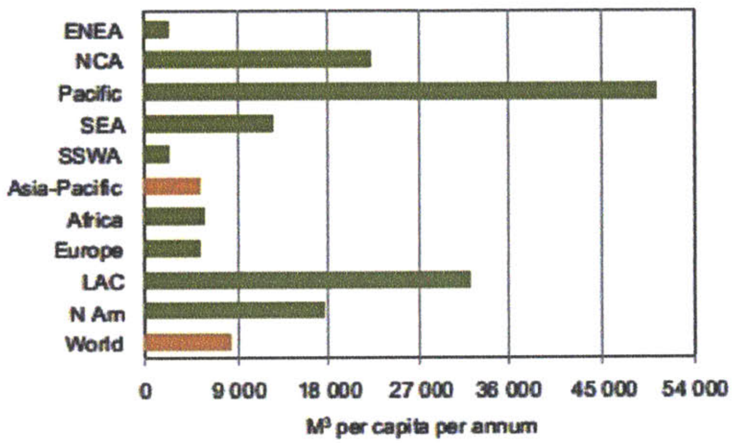
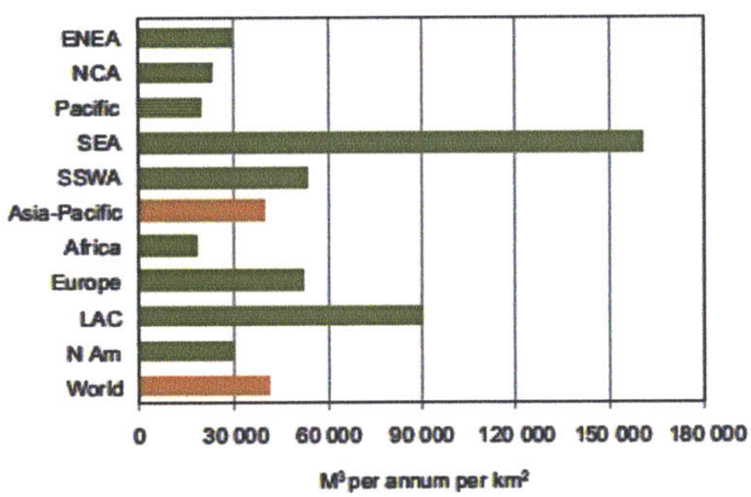


FIGURE 2.4b: Availability of natural resources per unit by area by world, region and sub-region, 2008
Source: UNESCAP, 2011



The availability and quality of fresh water supply is increasingly becoming a serious issue in many parts of the world. Considering present consumption patterns, it is estimated that by the year 2025, two out of three people on earth will live under water stressed conditions where they will experience moderate to severe shortages (UN, 2003). As of 2008, though the availability of South and South West Asia[9] (SSWA) was estimated at around 50,000m^3 per person/annum (which is relatively higher than other areas in the Asia-Pacific region), because of uneven access to freshwater and overpopulation, the actual availability of water resources was among the lowest in the Asia-Pacific region, at about 3,000m^3 per capita per annum (See figures 2.4a and 2.4b).

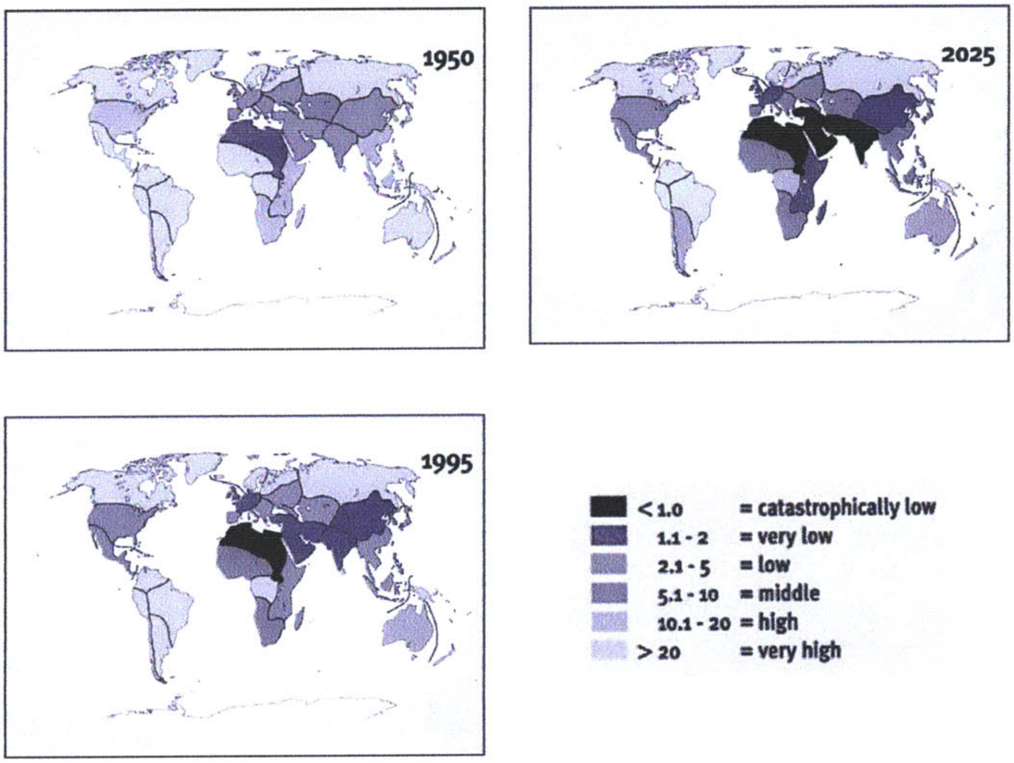
Moreover, according to UNESCAP projections, even of the relatively low figure of 3000m^3 recorded for South and South West Asia in 2008 will further deteriorate to reflect "catastrophically low" levels of less than 1000m^3 per person/annum, unless drastic action is taken (See figure 2.5).

Since the 1950s, quantity of water availability per person has declined by 80% (Asian Development Bank, 2001: 3). This deterioration can be attributed to many of the effects of climate change. For example, rising temperatures cause glacial retreat, which in turn reduces "blue water" runoff into the rivers of the Gangetic Plain, diminishing available supplies for consumption and irrigation. Moreover, reduced riverine flow will reduce not only the region's surface water supply, but also its already degraded groundwater recharge. Moreover, the region's rapid development—that generally fails to account for environmental ramifications—also adds to these problems, as poorly planned or unplanned development further alters the patterns of runoffs, which in turn affects groundwater recharge and disturbs the natural drainage channels (Alavian et al. 2009).

In addition, sea-level rise, which leads to saline contamination, will also have potentially irreversible impacts on the water supplies of these cities, particularly those in the coastal areas of Bangladesh and in cities located in the delta regions of the Cauvery, Indus, Krishna, and Narmada Rivers (Rahman, Majumder, Rahman, and Halim, 2011). In addition to impacts such as the actual loss of coastal areas, displacement of people, and economic devastation, salt-water intrusion into freshwater bodies and riverine systems will significantly degrade the potable water supply of these cities, leading to further scarcity. The projected population dislocations from flood-related events in Bangladesh are estimated to affect over 17 million people (Akter, 2009).

[9] Since reliable data for South Asia alone is not available, the estimates include South West Asia as well.

FIGURE 2.5: Global water availability in cubic meters per year (per thousand) for 1950, 1995 and estimates for 2025 Source: UNESCAP, 2011



The problem of water contamination will also be further exacerbated in the event of climate-related disasters such as floods and cyclones. During intense periods of rainfall or cyclonic storms, "flash flooding" has become a common occurrence in both Dhaka and Kolkata. When urban inundations occur, the already insufficient drainage systems of these cities often exceed their carrying capacity, and stormwater overflows into the cities' drinking-water supplies. This situation proves especially dangerous, as most of the mega-cities in South Asia have "combined" storm and sewer systems, not only reducing their individual storm-water and sewer-carrying capacities, but also increasing the likelihood of water-supply contamination whenever the system is even slightly taxed.

Changes in precipitation runoffs will have strong implications for the river systems and groundwater recharge in South Asia. For example, glacial melts and rise in precipitation are expected to increase the runoffs in the Ganges-Brahmaputra river basins, increasing the number and severity of inundation events, followed by a decrease in water flow after the glacial melts, where by 2050, the Brahmaputra and Indus Rivers will experience a decline in blue water runoff by 14% and 27%, respectively (IPCC, 2001). In South Asia, between 2041 and 2060, the annual runoff is predicted to increase by 20-30% over the runoff until 1970. This increase poses a serious threat to the recharge of water bodies and groundwater in this region, leading to further scarcity of water resources.

FIGURE 2.6a: Fresh water criticality index 2025, in case of a 10-percentile dry year on a watershed scale
Source: Alcamo et al., 1997

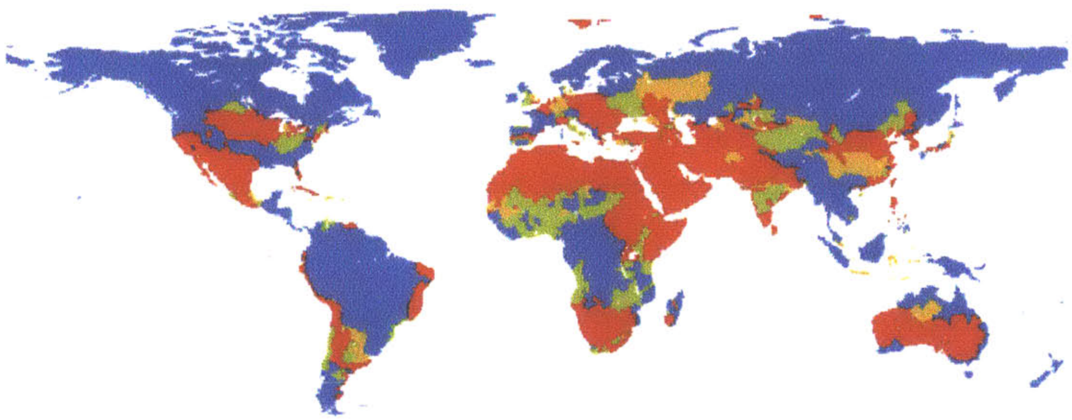
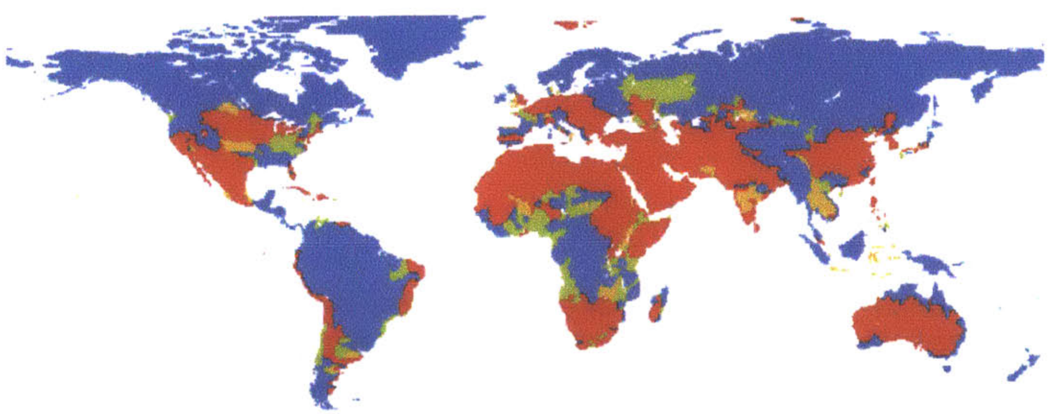


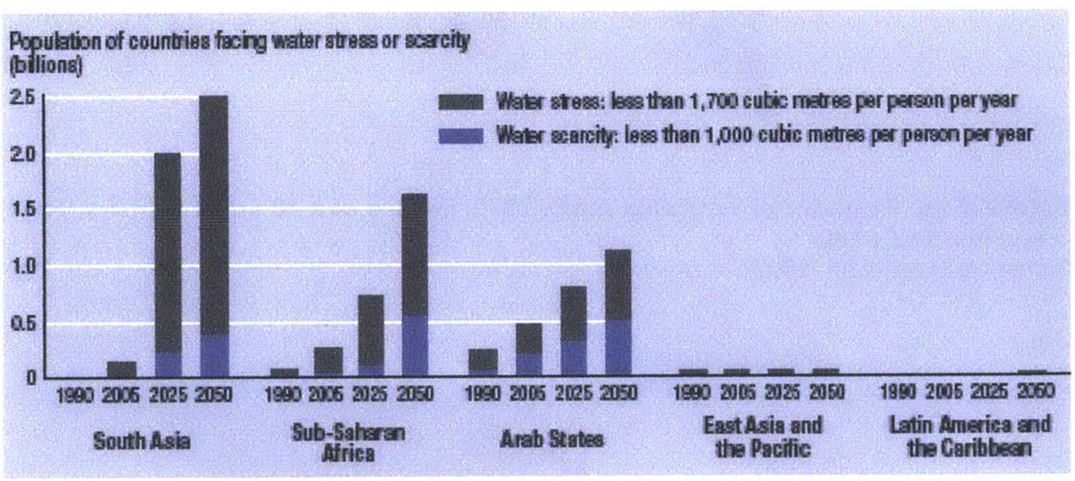
FIGURE 2.6b: Fresh water criticality index 2075, in case of a 10-percentile dry year on a watershed scale
Source: Alcamo et al., 1997



1: water surplus, **2:** marginally vulnerable, **3:** water stress, **4:** water scarcity

The figures above illustrate the dramatic increases in water scarcity, even by 2025, across much of the world. Within a decade, most of South Asia, like substantial areas of Africa, Australia, the Middle East, and North America, will be at the highest levels of vulnerability; by 2075, the situation will degenerate still further worldwide, with fully half of the world's population potentially suffering from critical fresh-water shortages. Not only potable water availability, but also the agricultural and aquacultural production may thus all decline precipitously, potentially worsening the region's water stress.[10] In 2012, the annual availability per person for South Asia was around 2,700 cubic meters, which was significantly closer to the threshold of water stress as compared to other parts of the world; for Europe and Central Asia, this number was at 13,000, while East Asia and the Pacific Region had 5,600 cubic meters of water available per capita per annum (Bucknall, 2007)

FIGURE 2.7. Projected Stress in Water Availability across Regions for the Years 2025 and 2050
Source: UNDP, 2006



Food Production

Much of South Asia's agricultural production takes place in the region's low-lying coastal and delta areas of the Indo-Gangetic Plain (which covers large parts of Pakistan, India, Nepal, and Bangladesh). However, it is

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[10] A region is considered water stressed when the availability of water is less than 1666 m^3 per capita per annum. Chronic water stress results when this is less than 1000 m^3.

precisely in these coastal and delta regions where the affects of climate variability are currently—and projected to be—most acute.

The Indo-Gangetic Plain, which encompasses almost 12 million hectares (over 29 million acres) of agriculturally fertile land, is known as the "breadbasket" of South Asia. This area produces the main staples for the entire region, including rice, wheat and other major cereal crops, which are grown in rotation. This agricultural production accounts for the principle source of food as well as livelihood security for several hundred million people[11] (Paroda et al., 1994; Aggarwal et al. 2004). According to FAO (2002), regional cereal production exceeded the total demand from 2002-2005; however, malnourishment was still widespread during this period because of the acute poverty and concomitant lower purchasing power of the people in this region.

Despite this prolific agricultural production, it is estimated that by 2030, South Asia will experience a deficit just in cereal production, by about 22 metric tons (FAO 2002); this gap can only be potentially bridged by yield increases, which remain unlikely under current conditions.

Three primary reasons will further contribute to the overall food deficit: rapid population growth particularly in the urban centers; loss of arable land; and availability of fresh water for irrigation. The two latter factors are a direct consequence of climate change and will also hamper efforts to increase crop yields to fill the gap between demand and supply.

In the next 30 years, considering a medium-growth scenario, the population is expected to increase by another 700 million (the current population of Europe), which will naturally raise overall food requirements exponentially. Just by the year 2020, demand on food grains alone is predicted to increase by over 50% (Paroda and Kumar, 2000; Aggarwal et al. 2004).

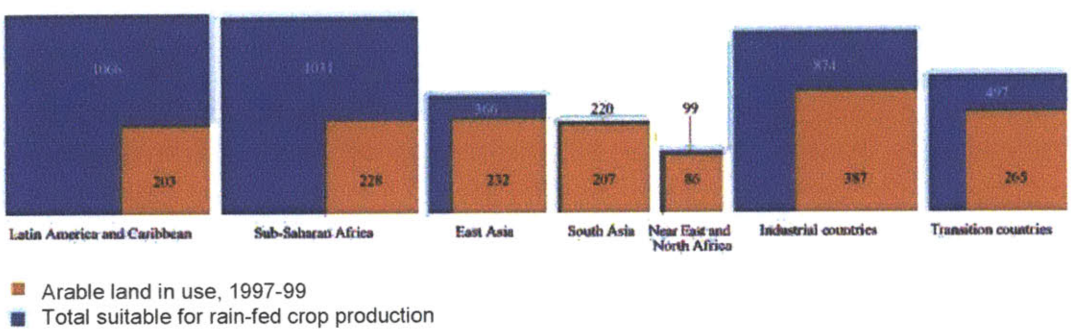
[11] Agricultural production represented about 35% of India's GDP in 2004, versus less 17% for China (UN Food and Agriculture Organization, 2004: 3). Though its share of GDP has declined consistently since then, agriculture is far more important to the economy of India than to perhaps any other developed or emerging country.

TABLE 2.4. Projected demand for food in South Asia for 2010 and 2020 assuming a 5% GDP growth and constant prices
Source: Paroda and Kumar, 2000

Items	Production (Mt) 1999-2000	Demand for food (Mt) 2010	2020
Rice	85.4	103.6	122.1
Wheat	71.0	85.8	102.8
Coarse grains	29.9	34.9	40.9
Total Cereals	184.7	224.4	265.8
Pulses	16.1	21.4	27.8
Food grains	200.8	245.7	293.6
Fruits	41.1	56.3	77.0
Vegetables	84.5	112.7	149.7
Milk	75.3	103.7	142.7
Meat and eggs	3.7	5.4	7.8
Marine products	5.7	8.2	11.8

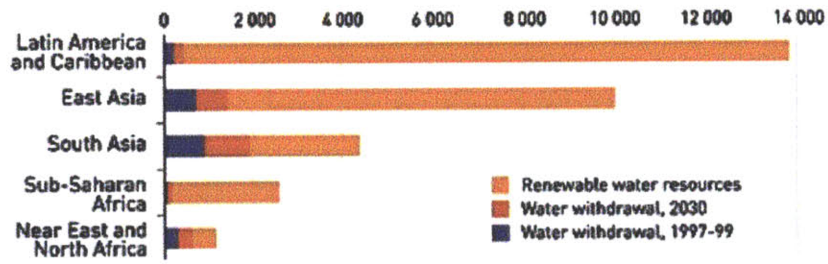
In South Asia by 1999, almost 86% of the arable land was already in use, leaving very little room for expansion of fertile land to meet the growing demands for food production (see figure 2.8).

FIGURE 2.8: Total available agricultural land and arable land in use by region between 1997-99
Source: FAO, 2002



Additionally, numerous factors—including reduced crop yields, truncated or altered growing seasons due to floods, tropical storms and droughts, diminished or contaminated water supply, saline water intrusion, decreased agricultural acreage through land subsidence, raised sea levels, and extended floodplain inundations arising from glacial melting--will all serve to weaken the region's food production. Moreover, greater unpredictability of the monsoon season will have additional ramifications, because this four-month rainy period accounts for 70% of South Asia's annual precipitation; 60% of agricultural land depends on the monsoons for water in this region.

FIGURE 2.9: Renewable water withdrawal (km³) in 1997-99 and 2030 (estimates)
Source: FAO, 2002



Projections indicate that by 2030, South Asia will be using 40% or more of its renewable water resources for irrigation, a widely established critical threshold at which countries in this region will be forced to decide between meeting agricultural or urban water demand, but not both (FAO, 2002).

The forecasts for aquaculture in South Asia are relatively positive compared to those for agricultural production. Aquacultural production in Bangladesh, for example, is expected to double 2004's levels by the year 2020, at 1.3M tons and is now growing at almost 10% annually. India in contrast, has not fared as well in this sector. Though production continues to increase, growth rates for Indian fisheries' output have been consistently declining since 1999, and International Food Policy Research Institute (IFPRI) forecasts will likely not be met as of 2020 (Brugère and Ridler, 2004).

The lack of steady food supply from surrounding agricultural and aquacultural areas manifests itself in higher food prices and curtailed supply for urban dwellers, particularly the poor, resulting in malnutrition and also threatening basic survival. An average household in urban South Asia allocates about 50% of its spending to food, as compared to 17% even in the United States, where most meals are prepared outside the home (World Bank, 2010).[12] With the likelihood of food shortages due to

[12] Food price inflation in South Asia varies considerably. For example in 2007-08, inflation in India was moderate, at about 7%, while in Nepal and Bangladesh it was significantly

deterioration in agricultural production in conjunction with the increased demands of a growing population, rising food prices will only add to the vulnerabilities.

In addition, reduced agriculture can also lead to loss of land and livelihood for rural farmers, who represent 60% of the labor force in South Asia (ILO, 2012). Such economic dislocation is a prime driver of migration[13] from rural to urban areas, increasing the population pressures of South Asian mega-cities.

Protection of Ecosystems

There are numerous ecosystems in South Asia, with an exceptional variety of biodiversity. Comprising 3.6% of the world's area, these ecosystems range from the Himalayan mountain ranges in the North, to the Thar Desert in the West. South India is home to some of the most diverse coral reef systems, particularly in and around the region's oceanic islands: the Maldives, Lakshwadeep Achipelago, and the Andaman and Nicobar islands (Bakus et. al., 2000; UNEP, 2001; Mohanty et al., 2008). India alone has a coastline of over 7000km and shares the territory for the largest mangrove forest of the world with Bangladesh (Selvam 2003) (Mukherjee et al. 2010). The flora and fauna found in these ecosystems comprise 16 and 21%, respectively, of the world's extant species (UNEP, 2001).

Though these eco-systems and their accompanying biodiversity closely impact climate change and offer a natural resilience to climate extremes, these habitats are disappearing at a rapid rate. Utilizing satellite time-series data, Coleman, Huh, and Braud (2008) found that the Ganges-Brahmaputra delta system lost 4290 square kilometers, over 35% of its total area, from 1996-2008, with nearly 82% of that loss directly attributable to agricultural and industrial encroachment. The system is currently losing about 6% of its area annually (Coleman, Huh, and Braud, 2008).

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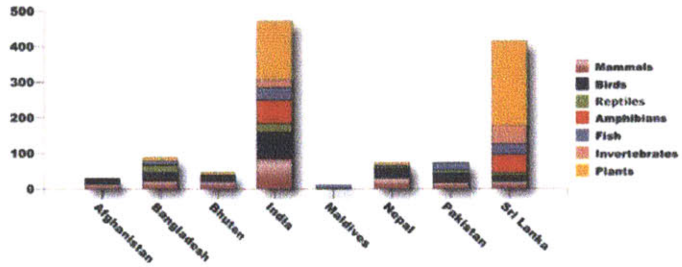
higher, at 15%. Pakistan, Sri Lanka and Afghanistan had the highest rates of inflation, which ranged from 20%-30%, with the latter two countries towards the top end of this range.

[13] Dhaka receives an estimated 300,000-400,000 migrants annually, most of whom are poor and uneducated.

FIGURE 2.10: Globally threatened species present in South Asia
Source: World Bank, 2009.



Though all these ecosystems are strong contributors to the ecological balance of this region, as discussed earlier in this chapter, the coastal mangrove forests and the urban wetlands have the most direct bearing on mitigating climate change in South Asia.

The protection of coastal mangrove forests is essential for a number of reasons, not just limited to balancing coastal biodiversity. These forests significantly benefit aquaculture, prevent coastal erosion, and act as natural bulwarks against cyclones and hurricanes (Mohanty et al. 2008). All these factors directly or indirectly benefit the coastal cities of South Asia, by directly ameliorating climatic disasters, supporting food production, and helping to secure rural livelihoods—thereby reducing rural migration into already overpopulated cities.

Mangrove forests covered approximately three-fourths of the coastline areas of tropical and sub-tropical countries, of which almost 50% have been destroyed or degraded, mostly by human activity (Sorensen, 2002; Mohanty et al., 2008). Though these coastal zones cover only 8% of the Earth's land surface, by 1994 these zones were home to a majority of the global population (Small, Gornitz, and Cohen, 2000). The fastest rate of growth in developing nations is in their coastal zones, where people of the lowest income groups reside (Sorensen, 2002); this pattern is also evident in South Asia. In addition to anthropogenic influences, climate-related impacts, such as sea-level rise and salt-water intrusion, disturb the biological cycles and contribute to the loss of natural environments, including the mangrove forests, thus furthering the decline in biodiversity.

Unsustainable patterns of development and expansion into peri-urban farmlands to accommodate a growing population also lead to loss of natural habitats, particularly urban wetlands, throughout the region. Many of South Asia's wetlands, including man-made wetlands and lakes, as well as natural depressions and drainage channels, have been destroyed by slum encroachment and development or been filled with waste (Gupta and Nair, 2010). In India, only about 30% of the original wetlands remain; much of the destruction has taken place in the last 50 years, corresponding to the country's period of rapid urban development (Gupta and Nair, 2011) These impacts on urban wetlands and natural habitats have further exacerbated the effects of climate change. of the near-ubiquitous construction projects in South Asia's urban wetlands have destroyed natural drainage channels, groundwater recharge zones, and retention ponds that could have otherwise captured run-off from heavy rainfall, reservoir discharges, snow melt, and floods. They also serve as non-structural climate adaptive elements; wetland vegetation can slow down floodwater flow and limit additional downstream flooding (Ramsar, 2004) while reducing the need for expensive infrastructure (Calder and Aylward 2006), such as water pumping stations and treatment plants. Moreover, some of the wetland ponds also support urban aquaculture, thereby contributing to the local economy. In addition, green areas and wetlands also help to regulate the micro-climate of densely developed urban centers and reduce the effects of urban heat islands.

Climate Events

Recent trends indicate that extreme climatic events have increased in frequency and intensity in Asia since the last century (see Table 2.6). These extreme events have manifested themselves in a range of climate-related disasters: *droughts*, *heat waves*, *cyclones*, and *intense precipitation* over shorter periods of time, which leads to *floods*. During this period many countries of Asia have experienced pronounced warming trends as well as significantly longer and more severe heat waves (De and Mukhopadhyay, 1998; Kawahara and Yamazaki, 1999; Zhai et al., 1999; Lal, 2003; Zhai and Pan, 2003; Ryoo et al., 2004; Batima et al., 2005; Cruz et al., 2006; Tran et al., 2005). In addition to these heat waves, droughts have increased in intensity in the summer and dry months, largely attributable to the rise in temperatures due to climate change (Webster et al., 1998; Duong, 2000; PAGASA, 2001; Lal, 2002, 2003; Batima, 2003; Gruza and Rankova, 2004; Natsagdorj et al., 2005). Apart from these heat-related events, the frequency of periods of intense rainfall has also risen drastically, leading to severe floods, particularly in urban areas, although the actual volume of total annual rainfall has declined in Asia (Zhai et al., 1999; Khan et al., 2000; Shrestha et al., 2000; Izrael and Anokhin, 2001; Mirza, 2002; Kajiwara et al., 2003; Lal, 2003; Min et al., 2003; Ruosteenoja et al., 2003; Zhai and Pan, 2003; Gruza and Rankova, 2004; Zhai, 2004). Precipitation in South Asia has thus decreased not only in absolute terms, but also, to an even greater degree, in its utility for agriculture and human consumption.

While findings suggest that tropical cyclones in the Pacific (Southeast Asia) have increased in both frequency and intensity (Fan and Li, 2005), the number of cyclones originating from the Arabian Sea and Bay of Bengal—which affect countries like India and Bangladesh—has decreased since 1970. The intensity of these South Asian cyclones, however has similarly increased markedly, and they have caused much greater damage (Lal, 2001).

TABLE 2.5: Summary of key observed past and present climate trends and variability in South Asia
Source: Adapted from Cruz et al., 2007

Country	Change in temperature	Change in precipitation
India	0.68°C increase per century. Increasing trends in annual mean temperature, warming more pronounced during post monsoon and winter	Increase in extreme rains in north-west during summer monsoon in recent decades, lower number of rainy days along east coast
Nepal	0.09°C per year in the Himalayas. 0.04°C in Teral region, more in winter	No distinct long term trends in precipitation records from 1948-1994
Pakistan	0.6°C to 1°C rise in mean temperature in coastal areas since early 1900s	10 to 15% decrease in coastal belt and hyper arid plains, increase in summer and winter precipitation over last 40 years in northern Pakistan
Bangladesh	An increasing trend of about 1°C in May and 0.5°C in November during the 14 year period from 1985-1999	Decadal rain anomalies above long term averages since 1960s
Sri Lanka	0.016°C increase per year between 1961 to 1990 over entire country, 2°C increase per year in central highlands	Increasing trend in February and decreasing trend in June

TABLE 2.6: Summary of observed changes in extreme events and severe climate anomalies in South Asia
Adapted from Cruz et al., 2007

Country/Region	Key trend
Heatwaves	
India	Frequency of hot days and multiple-day heatwaves has increased in past century; Increase in deaths due to heat stress in recent years
Intense rains and floods	
South Asia	Serious and recurring floods in Bangladesh, Nepal and north-east states of India during 2002, 2003 and 2004; a record 944mm of rainfall in Mumbai, India on 26th to 27th July 2005 led to loss of over 1000 lives with loss of more than $250 million; Floods in Surat, Barmer and in Srinagar during summer monsoon season of 2006; 17 May 2003 in southern province of Sri Lanka were triggered by 733mm rain
Droughts	
South Asia	50% of droughts associated with El Nino; Consecutive droughts in 1999 and 2000 in Pakistan and north-west India led to sharp decline in water tables; Consecutive droughts in 2000 and 2002 caused crop failure, mass starvation and affected 11 million people in Orissa; Droughts in north-east India during summer monsoon of 2006
Cyclones/Typhoons	
	Frequency of monsoon depressions and cyclones formation in Bay of Bengal and Arabian Sea on the decline since 1970 but intensity is increasing causing severe floods in terms of damages to life and property

Apart from these recent occurrences of extreme climate events, which have generally increased in intensity and frequency, projections indicate that heat waves and periods of intense precipitation are likely to continue throughout Asia as well (Emori et al., 2000; Kato et al., 2000; Sato, 2000; Lal, 2003; Rupa Kumar et al., 2003; Hasumi and Emori, 2004; Ichikawa, 2004; May, 2004b; Walsh, 2004; Japan Meteorological Agency, 2005; Kurihara et al., 2005). These events will be accompanied by more extreme fluctuations in annual rainfall during the monsoon, with significant implications for agriculture in particular (Lal et al., 2000;May, 2004a; Giorgi and Bi, 2005). Moreover, researchers forecast that a 2-4°C rise in sea-surface temperatures (relative to the current threshold temperature) will increase the intensity of tropical cyclones in South Asia by 10-20% (Knutson and Tuleya, 2004). The resulting stronger wind patterns, higher storm surges, ocean surface temperatures, and low-pressure systems translate into significantly raised risks of coastal disasters across Asia's shorelines (Kelly and Adger, 2000).

As a consequence of these extreme climatic events, public-health risks will also continue to grow. In South Asia, changes in climate may spread disease, especially vector-borne illnesses, as populations of mosquitoes and other insects move to new areas (Kelkar and Bhadwalan, 2007). In major South Asian cities, rising temperatures–compounded by urban heat-island effects—and intense precipitation will bring more frequent heat waves and floods, causing more fatalities and engendering possible regional pandemics (See Table 2.6).[14]

TABLE 2.7: Known effects of weather/climate and potential health vulnerabilities due to climate change in India
Source: Government of India, 2006

Health Concerns	Health vulnerabilities
Temperature related morbidity	Heat and cold related illnesses Cardiovascular illnesses
Vector-borne diseases	Changed pattern of diseases Malaria, filarial, kala-azar, Japanese encephalitis, and dengue caused by bacteria, viruses and other vector-borne pathogens
Health effects of extreme weather	Diarrhoea, cholera, and poisoning caused by biological and chemical contaminants in water (Currently about 70%of epidemic emergencies in India are water-borne) Damaged public health infrastructure due to cyclones/floods Social and mental health stress due to disasters and displacement
Health effects due to food insecurity	Malnutrition and hunger especially in children

These varied deleterious impacts are magnified in South Asia, where high population densities[15] and widespread poverty exacerbate these effects.

[14] The near-ubiquity of exposure to extreme weather events in South Asia makes the case for climate-change action in the region even more compelling; since 1990, more than 750 million people have been impacted by at least one natural disaster (World Bank, 2010)

[15] Excluding island nations and micro-states, Bangladesh has by far the world's highest population density—estimated at 1142 people/km^2 in 2010, an increase of 85% over the density in 1980 (619). In comparison, the 2010 figures for India and the US are 412 and 34, respectively (World Bank, 2013).

In the Indian states of Orissa and Andhra Pradesh, for example, a large number of heat-wave-related deaths have been reported in the past five years, mostly among poorer people (Nandi, 2012). Moreover, intestinal, viral, vector-borne, and bacterial illnesses, including dysentery, cholera, dengue fever, hepatitis, and malaria, become far more common when climatic and socioeconomic factors (among them poverty, poor water quality, limited hygiene practices, and insufficient sewer capacity) combine. (Durkin et al., 1993; Akhtar and McMichael, 1996; Bouma and van der Kaay, 1996; Colwell, 1996; Bangs and Subianto, 1999; Lobitz et al., 2000; Pascual et al., 2000; Bouma and Pascual, 2001; Glantz, 2001; Pascual et al., 2002; Rodo et al., 2002). The situation in South Asia's mega-cities will become even more critical if these issues of water availability and contamination, food security, and sustainable development are not addressed (Checkley et al., 2000).

KOLKATA AND DHAKA: CITIES AT RISK

The Low Elevation Coastal Zone (LECZ) of the world, defined as areas less than ten meters above mean sea level, occupies only about 2% of the Earth's land mass but is home to almost 10% of the world's population. 60% of this coastal population now lives in urban areas of the LECZ, which are highly vulnerable to impacts arising from climate change, including flooding, coastal erosion and sea-level rise. Moreover, these climate-related vulnerabilities, particularly in large or mega-cities of the Global South, are further complicated by many urgent social, economic and environmental challenges, ranging from poverty to reckless, poorly planned urbanization (World bank, 2011)

Located in this LECZ, Kolkata and Dhaka suffer from many of the same vulnerabilities that endanger other coastal cities in the developing world. This section begins by describing the primary factors that aggravate climate risk in each city and then provides an assessment of actual climate risks in the two cities. The overall aim is to outline the unique characteristics and major climatic risks—arising from both global-warming and societal factors—of each city in order to understand the overlapping areas of vulnerability that climate adaptation must address.

Kolkata

Kolkata, the capital of the State of West Bengal, India, is the economic, political, and cultural center of Eastern India[16]. The city proper, established in 1690 by the British East India Company, lies on the banks of the Hooghly River, part of the Ganges River system, which terminates in the Bay of Bengal. The Port of Kolkata, located within the city, is India's only major riverine port. The Port of Kolkata is the oldest operating harbor in the country and is the nation's third-largest in annual tonnage. The city's geographic position raises its level of vulnerability. Kolkata is located in the world's largest mega-delta[17], which the International Panel for Climate Change (IPCC) and others have identified as the region at greatest risk for the deleterious impacts of climate change (IPCC, 2007). Its location in the lower coastal region also makes it more directly susceptible to sea-level rise and storm surges, while experiencing corresponding increases in rainfall intensities and cyclonic storms. The OECD (2007) currently ranks Kolkata among the top ten cities globally for flood risk; by 2070, Kolkata is projected to top the list. Nearly unrestricted development means that currently about 15% of the city's population lives along the banks of the Hooghly River, rendering over 300,000 people highly vulnerable to tidal floods (Ghosh, 2010). Two principal factors—its geographic and developmental situations—thus mutually reinforce Kolkata's extreme vulnerability to such adverse climate events.

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[16] The official language of the state of West Bengal is Bengali, which is one of the twenty-two languages recognized by the Indian Constitution and is also spoken by the majority of the people in Kolkata. Kolkata also has literacy rates of 89.08% for males and 84.98% for females, which, although far below OECD levels, greatly exceed the national averages of 82% and 65%, respectively (India census, 2011). Nearly three-quarters of the city's population identifies as Hindu, with Muslims, Christians and other minority groups comprising the remainder. West Bengal is generally considered a secular state, one characterized by high literacy and overall civic engagement.

[17] Kolkata lies at the terminus of the Indo-Gangetic Plain, home to over one billion people, which includes the wide area linked by the Indus and Ganges river systems and extends from Karachi to Kolkata.

Primary Non-Climatic Factors Contributing to Climate Risk

Kolkata

Geographic

Coastal Location

The geographical location of Kolkata, which is about 60 kilometers north of the Bay of Bengal, exposes it to a range of coastal vulnerabilities. Moreover, the Sunderbans National Forest Preserve, the primary wetland system of the Indo-Gangetic Delta, is also located only 100km from the city, between the city and the sea. The Sunderbans, which contains the largest mangrove forest in the world, has historically been a natural buffer for the city against climate hazards such as cyclones and storm surges. The steady degradation of the mangrove forests however, may result in the loss of the natural protection that the mangroves provide to Kolkata.

Topographic Vulnerability

The physical territory of Kolkata originally consisted of swampy wetlands. Kolkata proper consists of a relatively narrow strip that extends for over twelve miles, primarily along the banks of the Hooghly River. Much of the city is located on largely flat terrain with little natural drainage; however, it does possess some unusual topographic characteristics. The terrain slopes away from the river on both the east and west banks, toward the marshy wetlands located on both sides of the city; this means that riverine flooding from the Hooghly has to pass through the city to drain into the wetlands. In recent years, development has encroached on the wetlands primarily on the Hooghly's west bank. In theory, the slope away from the riverbanks should help to carry the water from the tidal flooding away toward the marshes. However, since the western part of the city's wetlands has now been developed and paved over, the natural drainage channels as well as the marshy retention areas have receded considerably. In addition, the Kolkata development authorities have claimed a large section of the wetland areas to develop residential colonies, thus also degrading the city's inherent capacity to process runoff in an environmentally sound, cost-effective fashion.

Soil Conditions

This development-driven expansion into its swampy marshlands has not only resulted in further environmental deterioration, but also created risky conditions for urban dwellers residing in buildings constructed on unstable terrain. The inherent instability of the swampy marshland, already unsuitable for development, is further aggravated because of the soil conditions. The soil of the city is primarily classified as alluvial—characterized by layers of clay, silt and sand—as is the rest of the Ganges delta. The layering of clay soils with peat beds and other organic matter makes the soil exceptionally susceptible to compression and therefore prone to significant land subsidence, especially under the conditions of heavy groundwater extraction[18], as is the case currently in Kolkata (Chaterjee et al., 2006). Moreover, Kolkata also lies in an active seismic zone[19], which makes these buildings prone to collapse, and geological experts predict that rising sea levels will result in more frequent earthquake activity as well (Ghosh, 2010). By virtue of its low-lying position and proximity to the Indian Ocean, the city is categorized as a "very high-damage risk zone" for wind and cyclones (UNDP, 2005)

Developmental

Apart from the urban risks associated with the city's geographical location and unique topographical conditions, Kolkata's large population and widespread poverty also increases its overall susceptibility to climate change. The economic conditions both hamper efforts to devote much-needed public resources to climate adaptation and limit the resilience of the city's population.

[18] There is growing scientific evidence that groundwater extraction, especially in areas of low soil stability or high earthquake risk, substantially increases the likelihood of disasters. Most recently, the deadly earthquake that occurred in Lorca, Spain in 2011 was found to be a direct result of groundwater removal, where since 1960 the water table has lowered by 820 feet (Gonzalez, Tiampo, Palano, Cannavo, and Fernandez, 2012).

[19] According to the Bureau of Indian Standards, Kolkata lies in seismic zone III, which increases its vulnerability to earthquakes. (The Indian Meteorological Department has categorized the country into four seismic zones, where II is considered Low Intensity and IV is a very severe intensity zone. These zonal classifications are calibrated in accordance with the widely accepted Modified Mercalli Scale).

Population Growth and Density

The city's larger metropolitan area, known as the Kolkata Metropolitan Area (KMA), currently encompasses just over 1850km^2 of low-lying land, with elevations ranging from about 1.5 to 11 meters above sea level. The KMA has an estimated population of 14.7 million, with a third of that, or 4.75 million, residing in Kolkata proper (World Bank, 2010), making it the third-largest city of India. High rates of migration from the West Bengal countryside, poorer surrounding states, and neighboring Bangladesh have engendered greater crowding and slum conditions, with an estimated 3-4.3 million residents of the KMA living in substandard housing (Kundu, 2003), significantly exacerbating health and weather-event risks. The core city of Kolkata has a population density of about 23,100/km^2, more than twice that of New York City, and ten times that of Los Angeles (World Bank, 2010); density has risen significantly since economic liberalization in 1991, largely due to the aforementioned rural-urban migration. Housing and density issues thus aggravate climate- and natural-disaster risks markedly, in mutually reinforcing ways.

Though the natural population growth rate ranges from 1.8 to 2.6%, the overall population of the KMA will reach an estimated 20 million by 2021, with the increase, resulting primarily from in-migration, concentrated in the city's slum areas. These figures provide a grim picture of the overdevelopment in the most environmentally vulnerable parts of the city.

Poverty and Sub-standard Housing

Although almost one-third of the residents of the city proper, approximately 1.5 million people, live in the registered or unregistered slums of Kolkata, the city is ranked third in terms of its GDP among South Asian cities (PriceWaterhouse Coopers, 2009.), trailing only Delhi, India's political capital, and Mumbai, the nation's financial capital. (UN-Habitat, 2003) The GDP, in terms of purchasing power parity (PPP), is estimated at $150 billion; Kolkata moreover enjoys relatively low costs of living and thus high disposable income compared to other major cities of India (Rediff, 2010). If, as is often assumed, economic factors played a primary role, then Kolkata should enjoy significantly higher resilience, and be able to make greater strides in adaptation, than does a comparatively impoverished, yet otherwise similar city such as Dhaka. This research, however, suggests that the stronger economic situation of Kolkata has not translated into either greater resilience or more effective climate-change adaptation efforts.

Over-development

Like that of many other South Asian mega-cities, Kolkata's population is increasing rather rapidly, leading to unplanned land use, unregulated urbanization, and the resulting lack of green and open space. A study of the land use of areas managed by the principal planning body of Kolkata, the Kolkata Metropolitan Corporation (KMC), found that residential use accounts for 68% of the city area, followed by only 9.5% for parks and open spaces and 6% for industrial use; commercial, agriculture and transportation usage accounted for 5, 4, and 3% of the land, respectively.[20] In a city as densely populated as Kolkata, the lack of green and open spaces only adds to existing issues such as heat-island effects and air pollution. Kolkata's suspended particulate matter (SPM) levels are considerably higher than those of most other major cities, causing higher rates of asthma, bronchitis, and other respiratory ailments (Mittal and Van Grieken, 2001).

Other impacts that are equally deleterious but less visible include the deterioration of natural drainage channels and retention ponds, which could otherwise reduce water-logging, a major problem in the city. In a 2009 survey[21] of 600 Kolkata residents, almost 54% of respondents identified the lack of open space as a problem. It is also interesting to note that in the same survey, sanitation and water-logging also figured high on the list (see Table 2.8).

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[20] According to Mr. Ravi Menon, president of the Indian Tree Foundation, "The green-cover, which was more than 15% even until the late '80s, has come down to less than 3%, with mind-blowing real-estate growth." According to a study conducted in 2010 by KMC, of the 315 documented green spaces in Kolkata, almost half have been encroached upon; the KMC itself has been responsible for 24% of these encroachments. Another KMDA study found that many of the wards in the city do not even have 1% open space; according to a former GIS expert with the urban planning department of the city, Tapas Ghatak, these numbers were as low as 0.1%-0.3% in some wards.
For further information please see: http://articles.timesofindia.indiatimes.com/2012-10-15/kolkata/34471453_1_green-city-urban-recreational-forestry-green-activist-subhas-datta

[21] The survey was conducted by Bonani Kakkar of PUBLIC (People United for Better Living in Calcutta), a local NGO in association with *The Telegraph*, one of the city's leading newspapers.

TABLE 2.8: Kolkata residents' survey results, 2009 (Base: 600; Figures in percentage)
Source: The Telegraph, 2009

	Total recall of problems	Unprompted recall of problems	Seriousness of problem		
			Top rank	Second rank	Third rank
Power Cuts	80	43	15	20	15
Sanitation– garbage/sewage	73	48	16	18	12
Drainage/water-logging	70	45	19	12	11
Lack of open space/playground	54	10	1	6	7
Noise pollution	52	10	3	7	6
Domestic/piped water	50	32	22	6	4
Road quality	48	11	2	4	6
Vehicular traffic control	48	10	3	4	4
Air pollution	45	10	5	5	4
Pedestrian traffic control	36	7	3	2	2

Drainage Congestion

The pace of development has greatly exceeded the capacity of the city's existing water infrastructure, despite ongoing efforts to expand, a scenario which is mirrored in many cities of the Global South. This is particularly evident in Kolkata, in the city's inadequate and at times failing water, drainage, and sewer systems. According to a background study conducted in preparation for the Sewerage and Drainage Masterplan for 2030 by the Kolkata Environment Improvement Trust (KEIP, a subsidiary of KMC), almost 60% of the sewer capacity of all the trunk sewer lines of Kolkata has been blocked by silt. Moreover, the study also found that the entire sewer and drainage network was below capacity relative to current rainfall and that the existing pumping stations were inadequate not only during heavy rainfalls, but also during periods of high power consumption.

The increased precipitation patterns of the past decade, Kolkata's overdevelopment, and the city's inadequate sewer- and stormwater drainage [22] have caused excessive runoff, which in turn affects groundwater recharge. Moreover, the frequently elevated precipitation levels--that at times coincide with the high tides of the Hooghly River—cause frequent and severe "water-logging" in the city, primarily engendered through drainage-system congestion and deficient water-pumping infrastructure.

Availability of Fresh Water Supply

The city's rapid urbanization, while exacerbating its inadequate water infrastructure, is also depleting the city's water supply. The Sector Committee of Water Supply of the Kolkata Metropolitan Planning Committee estimates that KMA requires a water supply of 600 million gallons/day (MGD). Of the 600 MGD required, only 421.6 MGD of filtered surface water from the Hooghly River can be supplied to the residents under the current infrastructure conditions, creating a deficit of nearly 180 MGD per day. The remainder of the water needs is met through groundwater extraction,[23] which poses a serious health risk because of arsenic contamination. Moreover, a majority of the water extraction is largely unregulated and causing excessive depletion. According to the Government of West Bengal, there are currently 308 heavy-duty tube-wells and about 11,877 small-diameter tube wells in operation in the KMC area. Moreover, the physical expansion of the city into adjacent alluvial plains has exacerbated the existing problems of groundwater contamination[24] and soil erosion, because of higher demand, expanded

[22] Kolkata's "combined" sewer system, which merges waste- and stormwater discharge, is well over 100 years old. Deficient maintenance and insufficient expansion have resulted in regular problems of drainage congestion.

[23] According to numerous groundwater studies conducted by Jadavpur University's School of Environmental Studies of Kolkata, arsenic levels are on the rise. The University tested six tube wells and found over 190 mcg/liter (0.19 mg) of arsenic, considerably in excess WHO standards for safe drinking water. The levels of arsenic in Kolkata groundwater have been a point of strong contention between the research community and the city planning agencies; the latter continue to bore tube-wells to compensate for the deficit in the city's water supply. The KMC's information booklet on groundwater, published in 2003, reported only a "sporadic occurrence of arsenic beyond permissible limit (0.05mg/l) in ground water in a few places".

[24] Millions of KMA residents regularly ingest arsenic levels well in excess of acceptable levels, as suggested by the studies conducted by Jadavpur University. See the *Times of India* (2012).

agricultural activity, and diminished drainage capacity. Forecasts also indicate that Kolkata will experience significant saltwater intrusion over the next half-century, further degrading groundwater supplies, destroying much of the area's mangrove forest buffer, and halting the production of further protective alluvial deposits at the mouth of the Hooghly River. The surrounding region will experience similar, if somewhat less drastic, drops in agricultural and aquacultural production, but will be more prone to winter drought, as precipitation from December through February has declined significantly due to rising average winter temperatures.

Dhaka

Geographic

Locational

The city of Dhaka is settled in the same delta region as Kolkata, the two cities are just 152 miles (245 km) apart; Dhaka lies only 100 miles from the Bay of Bengal, part of the Indian Ocean, about twice as far as is Kolkata. Urban Dhaka, situated in the Ganges[25]-Brahmaputra deltaic plain, lies roughly at the geographic center of the nation and is fifty miles from the confluence of the region's two major rivers. The city's low elevation[26] makes its vulnerability to sea-level rise and storm surges even more acute than that of Kolkata, even though Dhaka is farther from the sea. Moreover, Dhaka is extremely prone to riverine flooding, since it is surrounded by numerous river systems.[27]. Additionally, like Kolkata, Dhaka is close to the Sunderbans mangrove forest, which is only 300 km (183 miles) away. Thus the mangrove forests also affect Dhaka indirectly in a number of ways; the most relevant include serving as natural buffers for coastal storm surges and cyclones and deflecting salinity intrusion to the delta river systems. Unlike Kolkata, which is the only major Indian city for quite some distance,[28] Dhaka is located very close to another major

[25] The Ganges River is known as the Padma once it enters Bangladesh from India.

[26] 70% of Dhaka lies less than 5m above sea level, with the city's highest point measuring just 12m above sea level.

[27] Four rivers circumscribe urban Dhaka: Buriganga to the south, Tongi Khal to the north, Turag to the west, and Balu to the east.

[28] The closest major Indian city is Lucknow, over 550 miles away.

urban center, the port city of Chittagong[29], which is only about 129 miles away. This proximity to Chittagong means that food, fresh water, and transportation all need to be distributed among a larger population in times of crisis.

Topographic

Developed primarily along the north bank of the Buriganga River, the metropolitan area of Dhaka covers an area of 360 km^2, while the larger district is about 1400 km^2. As is the case with the other rivers in the city, the Buriganga has become overly polluted, losing its ability to supply the city with fresh water. Moreover, its excessive riverbed silt deposits diminish the Buriganga's capacity to absorb floodwater flow[30], which adds to the problem of urban flooding. Though the government has begun to dredge the Buriganga's riverbeds, this problem greatly diminishes the city's resilience in the face of flooding.

The main geomorphic demarcations in and around the city include the "Dhaka Terrace," at a somewhat greater average elevation, the floodplains, which are considered the lowlands, and numerous depressions and channels. Dhaka has a more extensive riverine network than does Kolkata, enjoys numerous outlets to the sea, and possesses a larger area of wetlands and marshy areas scattered around the city. Since 70% of the city area consists of lowlands and wetland systems, Dhaka lacks suitable developable land. In a rapidly growing and densely populated urban area like Dhaka, the land shortage poses problems not only in managing its growth but also in protecting its environmentally fragile locations. Moreover, Dhaka is built primarily on clayey soil, interspersed with layers of sandy soil and red clay, which is high in compressibility and low in strength, which creates an unsuitable foundation for most urban construction, even in higher elevations. The factors that therefore made Dhaka a favorable location for twelve centuries—extensive river transport, abundant water supply, and prime agricultural land among them—now work against the city's survival.

[29] Chittagong is the second largest city of Bangladesh, with a population of approximately 4 million and density of 15,276 persons/km^2. Its total area is about one-third that of Dhaka.

[30] Since the Buriganga River serves as a principal waterway for inland transportation, its heavy siltation might severely limit upstream navigation, thereby making its economic and supply situations even more difficult.

Developmental

Population Growth and Density

Currently, the overall population of Dhaka is estimated at about 15.3 million, a figure expected to reach about 50 million by 2050 based on a conservative growth rate of 4% (Green City, 2005). The rate of in-migration to Dhaka from rural areas of the country is estimated at 300 to 400 thousand people per year (Bangladesh Bureau of Statistics, 2011). According to the 2006 census, the population density, averaged across developed, developing, and fringe areas of Dhaka city, was 7,956 persons per km^2; the developed areas of the city proper have the highest density of about 34,598 persons/km^2 (World Bank, 2007). Most migrants come seeking employment, which is largely concentrated in Dhaka; fully 80% of the nation's businesses are located in the city, principally in the garment industry (WTO Secretariat, 2013).[31]

Poverty and sub-standard housing

About one-third of the city's population lives below the poverty line, surviving on less than $3 a day; many of the poor live in the 4966 slum clusters (up by 341% since 1998, when there were 1125 such clusters) that are scattered around the city. The slums are even more densely populated; estimates suggest average densities of as high as 200,000-people/ km^2 (World Bank, 2007, Centre for Urban Studies, 2005). Since these slums tend to be concentrated in the most flood-prone areas, major inundations prove especially life threatening in Dhaka (Braun and Aßheuer, 2011).[32]

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[31] According to the WTO Secretariat, the garment and textile industry accounts for 77% of Bangladesh's exports, with four-fifths of those in this industry. Dhaka is ideally suited for clothing production, as its climate is currently ideal for jute and cotton production.

32 Braun and Aßheuer found in a recent study that 70% of households surveyed experienced substantial property damage, 75% were thrown out of work, 57% experienced severe illness, and 90% were forced to curtail their food intake significantly during flooding events. Increasing slum population density and flooding frequency will further exacerbate these levels of deprivation.

Overdevelopment

Unregulated urban growth to accommodate expanding populations has also contributed greatly to the vulnerability of the city. Increased risks arise from urban floods due to lack of natural drainage, unequal, inadequate distribution of basic urban services, skewed development patterns, dangerous densification in low-lying slum areas, and construction of high-rises on reclaimed, marshy land, further destabilized by groundwater extraction. [33] Numerous other potential natural disasters, including earthquakes, compete for resources and attention in building resilience and reducing vulnerability.[34] The fact that the city of Dhaka has only one major road—in which traffic is backed up for an average of six hours every day—that is available to emergency services as well as private and public vehicles, makes matters even worse in case of catastrophe, insofar as rescue efforts cannot be deployed in a timely and effective manner simply because first responders cannot reach affected residents.

Since the city has experienced rampant, unplanned development, only 14.5% of Dhaka is open space, whereas larger cities with similar characteristics should have more than 20%. Although the Bangladesh Open Spaces and Wetland Protection Act of 2000 forbids the development of parks, open spaces, and wetlands, illegal encroachment on such areas by powerful real-estate conglomerates and other private development entities continues relatively unabated. [35] The political access

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[33] One of the city's leading newspapers, *The Daily Star*, issued a report in 2010 that details the hazards of the construction of high-rise buildings in Dhaka. Drawing on detailed geological surveys and the work of prominent geological experts, the report warns, "It may not even need an earthquake for these multi-storey buildings to come tumbling down. Heavy rains after a long spell of dry weather may prove enough to make them topple over," causing severe property and infrastructure damage as well as extensive loss of life. The full transcript of the report is available at http://www.thedailystar.net/newDesign/news-details.php?nid=141744.

34 According to a GoB government study from January 2010, an earthquake of magnitude 6 would level nearly 80,000 buildings (and damage even more), while a 7.5-magnitude earthquake would likely generate 30 million tons of debris and result in over 130,000 immediate deaths and hundreds of thousands of serious injuries. The detailed study also that indicates that such a major earthquake would destroy at least ten major hospitals and ninety schools, while severely damaging hundreds of other hospitals, police stations, and fire stations.

[35] See, for example, Raihan and Kaiser (2012) for an analysis of the process of encroachment.

and unspoken support of government planning agencies that these business entities enjoy therefore accelerate the overall environmental degradation and increased climate-change susceptibility of Dhaka.

This unregulated and deleterious pattern of growth has also factored into the increased urban flooding of Dhaka; unchecked development has led to increased surface runoff, as the processing capacity of water bodies, marshy areas and natural drainage channels has been progressively closed off. While the Detailed Area Plan (DAP) for Dhaka clearly identifies demarcations for wetlands, waterways, and open public spaces, the lack of specific guidelines, exacerbated by political pressure from powerful developers, prevents such enforcement, resulting in the continued loss of wetlands and thereby aggravating inundation threats (Moinuddin, 2010).

Drainage Congestion

Dhaka is exceptionally susceptible to climate-change risks, particularly by floods, sea-level rise, and storm surges, dangers exacerbated by the city's accelerating population growth and geographical location. The marshy and low-lying location of Dhaka, marked by a network of rivers and streams and bordered by four major tidal rivers, greatly enhances its vulnerability to flooding. Moreover, the city's frequent cyclones and tornadoes, increased duration and intensity of recent rainfall, and an inadequate flood barrier and storm water system aggravate the city's impacts from flooding even more. During abnormally strong monsoons, about 75% of the city becomes waterlogged, while some parts become completely submerged.[36] While the poor design, insufficient upkeep, and limited capacity of the city's sewerage and stormwater systems contributes greatly to the deleterious effects of flooding (Masud, 2011), development is generally the principal cause of drainage congestion, as construction on the fragile yet invaluable wetlands diminishes natural capacity to deal with flooding. [37] Under Dhaka's FAP, various measures,

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[36] Flooding in the city of Dhaka has been a recurring problem; the 1987 and 1988 floods, which impacted the city for about three weeks, occupied an area of about 250 km^2. Though subsequent floods have affected a smaller portion of the city (about 90 km^2), these more recent inundations have persisted for longer periods of time, about eight weeks in 1998 and again for about three weeks in 2004 (3CD City Profiles Series, 2006).

[37] The construction of the Riverview, Bashundhara, Mohammedia, and Bashumoti housing estates in Dhaka, for example, resulted in the destruction of hundreds of acres of wetlands, lakes, and ponds over the past fifteen years (Yahya, et al., 2010).

including the building of embankments, drainage pumps, and flood-proof, higher elevation dwellings, as well as dredging of canals, have somewhat narrowed the impacts of flooding (Shah, 2008). The current state of drainage in Dhaka nevertheless is critical, especially for the most vulnerable populations, greatly exacerbating the localized impact of inundation events.

Availability and quality of fresh water supply

In addition to the problems caused by poor drainage, increasingly concentrated precipitation and rising sea levels are already threatening freshwater availability, even while groundwater extraction[38] intensifies due to rapid population growth and food-production pressures. The mismanagement of water resources in and around the metropolitan area has also significantly constrained the water supply for the residents of Dhaka. Tragically, though Dhaka is located in the watershed of three major rivers and surrounded by rivers on all four sides, the plentiful surface water—which would otherwise have been more than adequate for the city's needs—cannot currently be used for consumption. To a large degree, the change in land-use policies in 1995 (per the Dhaka Structure Plan), coupled with unregulated growth and illegal pollutant discharge, has been responsible for polluting the city's river resources.[39] As a result, there

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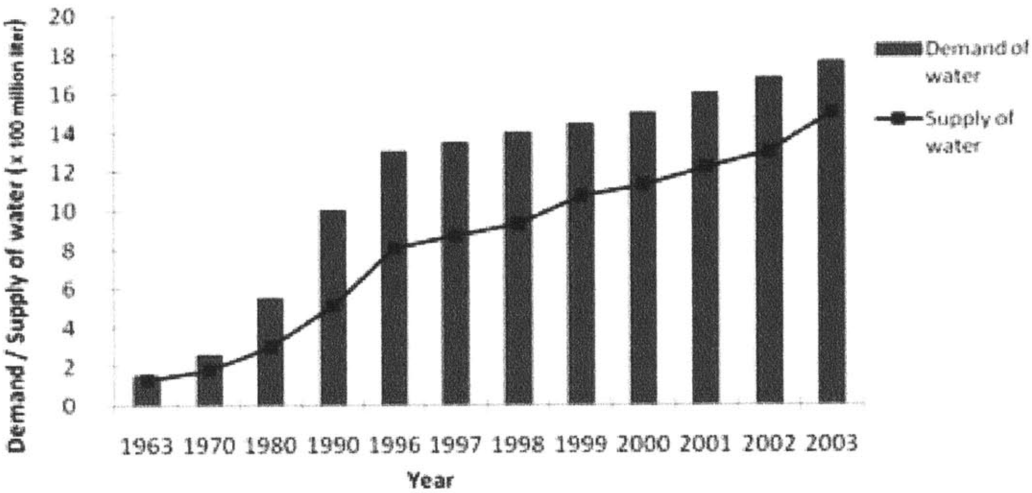
[38] The water table in greater Dhaka has lowered by twenty meters over the past three decades, largely because well extraction has increased by 90% during the period. Rampant improper discharge of industrial and residential waste into waterways and swamps has contaminated numerous water sources around the city as well (3CD City Profiles Series, 2006).

[39] The Dhaka Structure Plan (1995) characterized certain industrial areas as underdeveloped, largely because of mismanagement and insufficient infrastructure upkeep by the Bangladesh Small and Cottage Industries Corporation (BSCIC). To address these problems, the Plan allowed certain businesses to establish operations outside of the previously sanctioned zones; given rising real estate costs in the industrial zone, numerous commercial concerns opened facilities throughout the watershed. Several researchers, including Dasgupta and Marr (2007), have identified certain sectors as the largest contributors to industrial pollution: textiles (particularly the washing, dyeing, and printing of fabric), chemical production, and oil processing. Taken together, these industrial activities account for 60% of the watershed's pollution, which consists of organic and inorganic waste, including heavy metals. Almost all the surface water, including ponds and canals, of this area not only contains toxic industrial wastes, but also shows very high COD and BOD levels (chemical oxygen demand and biological oxygen demand, respectively), which are measures of the relative oxygen-depletion effect of a waste contaminant) and e-coli content due to untreated sewage disposal. It is estimated

is an overwhelming reliance on groundwater, which meets over 80% of the water demands for the city.

FIGURE 2.11: Demand, supply and deficit of water in Dhaka city (1963-2003)
Source: DWASA



As the chart above shows, although the Dhaka Water and Sewer Authority (DWASA) has consistently expanded its water supply, its provision has nonetheless fallen considerably short of demand, despite heavy reliance on groundwater drilling. As of 2007, DWASA operated 453 heavy-duty tube-wells, while ~1300 additional privately owned wells are in use in the city. This unsustainable dependence on groundwater has already caused a substantial lowering of the water table; the level continues to decrease at the rate of two to three meters per year (Dhaka State of Environment Report, 2005). Concerns regarding water supply are not limited to issues of scarcity; numerous studies indicate that chemicals and dissolved organic solids have contaminated not only the surface water, but also the groundwater in Dhaka (IWM, 2007). In 2003, Dhaka had a daily water deficit of 260 million liters, which has grown significantly since then (Integrated Water Resources Management Options for Dhaka City, 2010). This figure moreover only accounts for those with access to piped water supplies. Of the city's millions of slum dwellers, only 27% have access to

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that about 330,000 kg of BOD is discharged into Dhaka's watershed everyday (IWM, 2007). The pollution levels in the watershed are so extreme that they exceed the current technological capacity for rendering the water potable.

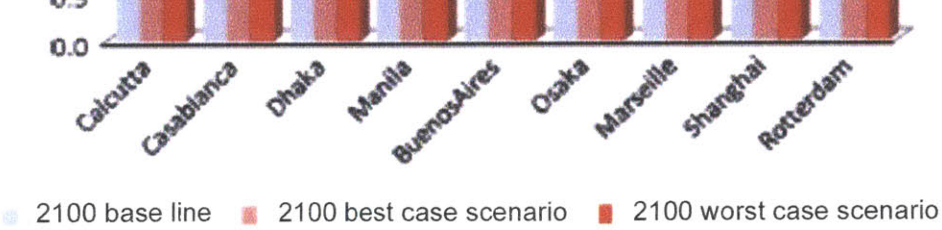
running water, compared to 83% of the wealthier residents (World Bank, 2007). The issue of water supply is therefore also one of social justice and equity.

Water-Related Climate Impacts for Dhaka and Kolkata

Floods

Several studies conclude that, among the numerous climate risks that Dhaka and Kolkata face—e.g., land subsidence, sea-level rise, and salinity intrusion—urban flooding will be the most critical as the effects of climate change increase (Dasgupta, Gosain, Rao, Roy and Sarraf, 2012). Increased levels of, and more frequent local precipitation, in conjunction with Hooghly River high tides, land subsidence, increased cyclonic activity and coastal storm surges—all intensified by climate change—will further exacerbate Kolkata's flooding.

FIGURE 2.12: Climate change impacts scenarios on hydro-geological component of CCFVI of most vulnerable coastal cities
Source: Balica, Wright, and Van der Meulen 2012

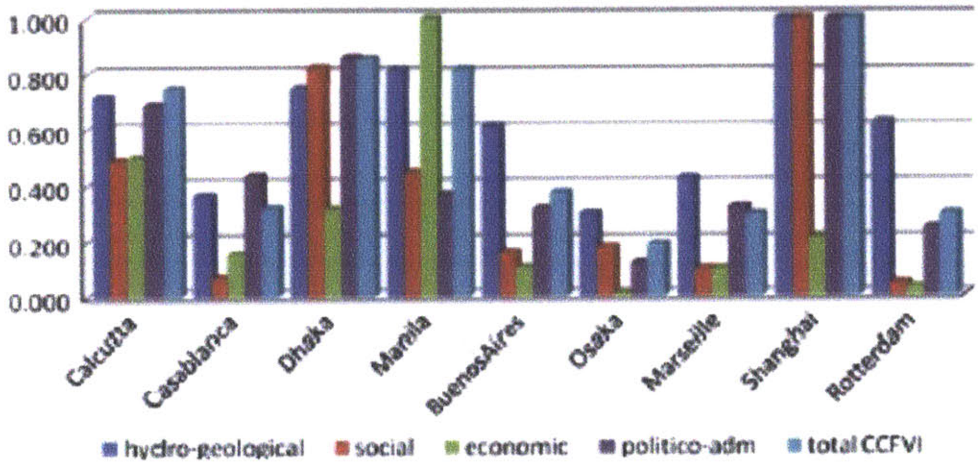


The Coastal Cities Flood Vulnerability Index (CCFVI) developed by the authors calculates a measure of inundation risk that draws upon nineteen separate indicators, utilizing measures of exposure and susceptibility versus resilience. The best-case scenario uses the modeling of Jian (2008), while the more realistic (worst-case) scenario draws on OECD

(2007) projections. Kolkata and Dhaka, starting from a position of high vulnerability, will remain at very high (>1.5) risk even under favorable conditions. Apart from these hydro-geological causes, the cities' vulnerability to flooding is further exacerbated by the poor drainage infrastructure, where the entire drainage networks only cover 55% and 39% of Kolkata and Dhaka, respectively. Moreover, siltation and poor maintenance of available channels, construction-related disruptions in storm-water flow, and development of the surrounding marshlands—ecological resources that had historically served as natural drainage areas—all aggravate water-logging during floods.

A recent World Bank study (2011) for Kolkata finds that inadequate maintenance and siltation of trunk sewer systems over time have created a highly vulnerable situation for the city; while during dry season the systems are still able to maintain baseline hydraulic capacity, during wet seasons, even under what previously were normal levels of precipitation, the systems are unable to accommodate runoffs. The report further estimates, admittedly quite conservatively, that "the damage from a 100-year flood will increase by about $800 million to more than $6.8 billion in 2050 due to climate change (A1F1 scenario)". In their study Balica et al. (2012) also find that presently, Dhaka and Kolkata rank second and third respectively (among the nine most vulnerable cities in mega-deltas) in terms of their social (e.g., population and poverty) and politico-administrative (including infrastructure and planning) components, accounting for the varied urban risks for both cities discussed earlier in the chapter.

FIGURE 2.13: Current vulnerabilities of most exposed coastal cities
Source: Balica, Wright, and Van der Meulen 2012



Currently, the concentrated summer monsoon rains make both cities highly prone to seasonal flooding; in the past decade, the intensity of rainfall has also increased markedly. Historically, Kolkata has received an average historically of over 1500mm of rainfall annually, with 80% of the total from June to September; these rains are caused mainly by the Southwest monsoons coming in from the Bay of Bengal (Linacre and Bart, 1997). In addition, the city also experiences severe early-summer convective thunderstorms, known locally as *Kal baisakhi* (Peel, Finlayson and McMahon, 2007).

Rainfall patterns in Dhaka are also somewhat similar though a bit more dispersed throughout the year, which keeps the annual mean relative humidity of the city rather high, at about 65%. The rainfall throughout the year results primarily from the Southwest Monsoons between June and September, tropical storms from April to June and from September until December, and tornadoes, which bring varying intensities of rainfall[40] throughout the year, However, of the annual average rainfall of about 1850 mm (seventy-three inches), approximately 80% comes in the monsoon season between May and September, similar to the situation for Kolkata.

[40] Tornadoes are a major concern for the country, as globally, only the US experiences more tornadoes annually than does Bangladesh, although the US has sixty-six times more land area than Bangladesh, which is smaller than 93 other nations.

In recent years, though the mean monthly rainfall has been variable in Kolkata, where in 2001 it was recorded at 117.17mm, after 2001 it has shown a steep upward trend. The average monthly rainfall in 2007 was 195.34mm, an increase of 61.55mm from the recorded rainfall in 1981 (see Table 2.9)

TABLE 2.9: Changing Temperature and Precipitation in Kolkata
Source: Census of India, 2001

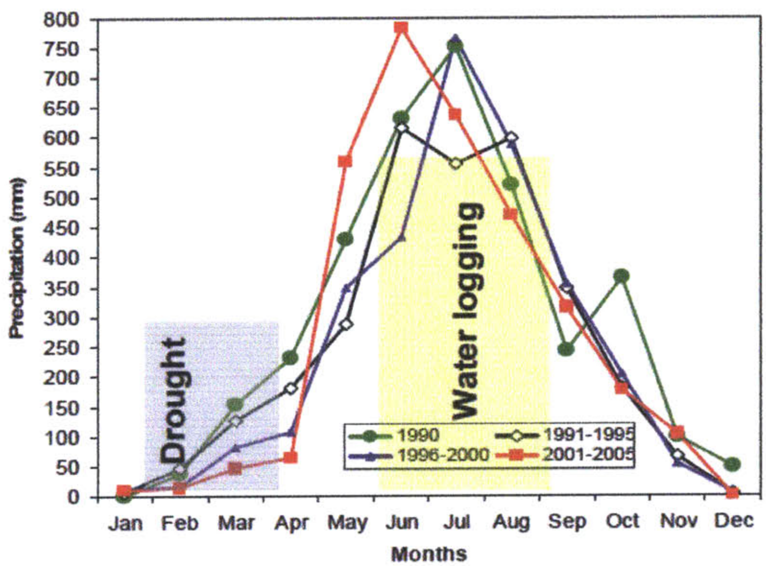
Year	Average Temperature (°C)	Average Rainfall (mm)
1981	30.28	133.79
1991	31.61	146.77
2001	31.39	117.17
2007		195.34

Moreover, based on the KEIP data of Kolkata's rainfall activity, Dasgupta et al. (2012) extrapolated a model for 10-, 30-, 50- and 100-year return periods (See 2.10), which show an increase in rainfall (in mm) with each progressive scenario while the duration of the rainfall remains the same. This would mean that flash flooding would become even more severe in a given period of time as the effects of climate change begin to intensify.

Weather trends in Dhaka also demonstrate strong variability; the city's precipitation concentration has been rising markedly, even more so than in Kolkata. For example, between 1990 and 2009, the average annual rainfall actually decreased from 2103 to 1930mm, but the monthly average rainfall for July and August, which had been 567 and 227mm, respectively, in the 1990s, sharply increased to 676mm and 482mm, respectively, in the 2000s (Bangladesh Meteorological Department, 2009; ICEAB, 2010).

Since 2010, however, there has been an upward trend in precipitation, where Dhaka experienced a total precipitation of 6252 mm (246 inches) in 2009 and 5016 mm (198 inches) in 2010, representing rainfall levels that were 233% and 171% above normal, respectively. New York City, by comparison, averages forty-four inches annually. During the 2004 floods, about 341 mm of rain (13.4 inches) fell in a span of 24 hours, while more recently, in 2009, Dhaka received 333 mm (13.1 inches) on a single day, with the highest-ever hourly rainfall recorded at 162mm (Bangladesh Meteorological Department, 2009). Figure 2.15 shows the effects of increased rainfall concentrations between June and August, identifying the frequency of water-logging, which contributes to the overall vulnerability.

FIGURE 2.15: Monthly average rainfall of Dhaka
Source: IUCN, 2011



Projections from a recent study by Dasgupta et al. (2012), indicate that this increasing trend in precipitation is likely to continue; by 2050, it is estimated that precipitations will increase by 16% and 11% in the A1F1 (high emissions) and B1 (moderate emissions) scenarios, respectively.[41] Additionally, a study of storm patterns conducted by KEIP in 2007 shows that rainfall intensities peak within a regular rain shower at least 4-5 times daily during the monsoon season, leading to floods caused by water logging (KEIP, 2007).

The scenarios with climate change effects, which are likely to rise with the growing emissions, also pose a grim picture for Kolkata. Dasgupta et al. (2012), in their study on Kolkata's flood impacts, provide further projections on the increases in percentages of the area and population that will be affected in a 30-, 50- and 100-year period along with the

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[41] These estimates utilize comprehensive analyses of the scenarios in the IPCC Fourth Assessment Report (JICA 2008) to provide the basis (best- and worst-case scenarios) for estimating climate change under conditions of high uncertainty. Nakicenovic and Swart (2000) provide a full description of the emissions scenarios.

duration and depth of inundations. For example, in the KMC, for flood depths greater than 0.25m[42], in a 30-year, high emissions (A1F1) scenario, the percentage of the total population affected increases to 41%, and then to 44% and 47%, in the same scenario, for 50- and 100-year estimates, respectively. Likewise the area that is affected under the same A1F1 scenario for 30, 50 and 100 years will also increase to 7%, 10% and 15%, respectively (see table 2.10).

TABLE 2.10: Scenarios for area and population exposed to flood depths <0.25 meters
Source: World Bank, 2011

	Flood return period scenarios								
	30yr	30-yr +A1F1	30-yr +B1	50-yr	50-yr +A1F1	50-yr +B1	100 yr	100 yr +A1F1	100 yr +B1
KMC: area affected in million km². (%)	63 (34%)	65 (35%)	64 (34%)	67 (36%)	72 (39%)	70 (38%)	72 (39%)	76 (41%)	75 (41%)
KMC: population affected in millions (%)	1.99 (39%)	2.11 (41%)	2.07 (41%)	2.14 (42%)	2.24 (44%)	2.19 (43%)	2.28 (45%)	2.42 (47%)	2.38 (47%)

Moreover, a study that compared the duration and severity of flooding episodes over the 100-year time frame without climate-change impacts to those under the A1F1 projections found that the peak inundation levels occurred significantly earlier in the flooding episode under A1F1 (Dasgupta et al., 2012). This analysis points to two primary risks. First, the actual flooding depths will become greater with the effects of climate change over time; this will increase the level of property damage (through deeper submersion) and also pose higher mortality risks. Secondly, since the floods waters will get deeper in earlier phases of flooding, it will allow even less time for residents to escape or for emergency services to rescue people.

[42] Flooding levels of less than 0.25m generally cause little damage, since most residents are experienced in adapting to minor flooding and since most buildings are constructed to account for this flooding level (Dasgupta et al., 2012).

The primary hydrological cause for such urban flooding in Dhaka differs from that for Kolkata, which is generally limited to excessive precipitation, sometimes coinciding with high riverine flooding of the Hooghly. In Dhaka, flooding is also exacerbated by the rise in the peak water levels of the rivers that bound the city, in turn also increasing the flood peaks and duration and further intensifying risk.

According to their study "Impact of Climate Variability on Flood Management in Dhaka City" which employs hydrograph analyses, Faisal (2006) find that, under a high emissions scenario, the projected peak discharge and runoff for major rivers, water levels in rivers surrounding Dhaka, and increased precipitation from June to August[43] will all contribute greatly to the risk of flooding for Dhaka. For example, around three highly vulnerable locations of Dhaka (Hardinge Bridge, Bhadurbad, and Bhairab Bazaar), which are directly affected by the three major rivers of Bangladesh, Kabir and Faisal (2006) find that overall flood water levels (peaks) will not only increase between 1990-2030 and 2030-2050, but that the water will remain above the danger levels for substantially longer periods. Their models indicate that in 2030, floodwater will remain above danger levels for 35, 30, and 22 days in Hardinge Bridge, Bhadurbad, and Bhairab Bazaar, respectively. By 2050, those levels were estimated to further increase to 61, 66, and 38 days, respectively. As shown in Table 2.11, percentage change in peak and flood levels for these three areas will increase substantially from 1990 values. In Bhairab Bazaar ,which is affected by the discharges of the Meghna river, in 2050 the peak will increase by 23.71, while the duration of the floods will increase by 322% over that of 1990.

TABLE 2.11: Scenarios for percentage changes in flood peak and duration
Source: Kabir and Faisal 2006

	2030		2050	
	Peak	**Duration**	**Peak**	**Duration**
Hardinge Bridge, Ganges	0.14	169.23	1.72	369.23
Bahadurabad, Brahmaputra	1.30	100	4.80	340.00
Bhairab Bazar, Meghna	18.23	144.44	23.71	322.22

[43] The authors' global-warming projections assume a 1% increase in CO_2 concentrations annually.

Similarly, in the four rivers that directly surround Dhaka city—the Buriganga, Turag, Tongi Khal and Balu—peak water levels are expected to rise and flood the city (see Table 2.12). The rise of the Balu River will have the most impact; in 1990, at high flood levels the Balu was at 5.34 meters, while in 2030 and 2050, the levels are estimated to reach 9.61 and 9.72 meters, respectively.

TABLE 2.12: Projected peak water level for rivers surrounding Dhaka compared to high flood levels in 1990
Source: Kabir and Faisal 2006

River	**1990 HFL (m)**	Effect of Brahmaputra		Effect of city runoff		Expected water level		Existing embankment height (m)
		2030	**2050**	**2030**	**2050**	**2030**	**2050**	
Buriganga	5.36	5.44	5.55	4.19	4.20	9.63	9.75	**9.40**
Turag	5.35	5.43	5.54	4.19	4.20	9.62	9.74	
TongiKhal	5.33	5.41	5.52	4.19	4.20	9.60	9.72	
Balu	5.34	5.42	5.53	4.19	4.20	9.61	9.72	

TABLE 2.13: Projected weekly rainfall during peak months from June through July in Dhaka City for 2030 and 2050, compared to rainfall in 1990.
Source: Adapted from Kabir and Faisal 2006.

Month	**Week**	**Rainfall 1990 (mm)**	**Rainfall 2030 (mm)**	**Rainfall 2050 (mm)**
June	1	5.43	6.03	6.95
June	2	13.71	15.22	17.55
June	3	7.12	7.90	9.11
June	4	6.42	7.13	8.22
July	1	0.43	0.48	0.55
July	2	37.57	41.70	48.09
July	3	5.14	5.71	6.58
July	4	14.29	15.86	18.29
July	5	26.57	29.49	34.01
August	1	9.29	10.31	11.89
August	2	2.43	2.70	3.11
August	3	13.28	14.74	17.00
August	4	6.43	7.14	8.23
August	5	2.00	2.22	2.56

Projections for 2030 and 2050 for both cities thus clearly indicate not only increased flooding for both cities, but also greater intensity (depth of inundation levels) and duration. In Dhaka, the impact to flooding will be more severe, both because average rainfall will rise during June through July—which will add to the existing drainage congestion—and because external flooding will result from increased discharges and higher water levels from its major rivers.

Floods are therefore becoming more critical risks for both Dhaka and Kolkata. Not only do the future scenarios predict increased flooding, but the recent trend of events also point to it. The history of major floods that have occurred in West Bengal and have affected Kolkata very seriously shows that the frequency and intensity of floods have risen. For example the first major flood in the 1970s occurred in 1978 followed by another one eight years after in 1986. However, since 1999, these flood events, most caused by intense periods of rainfall within short intervals, occurred in quick succession. In the 2000s, large floods in Kolkata occurred in 2000, 2001, 2004, 2006 and 2007, all of which caused severe damage and claimed many lives (see Table 2.14).

TABLE 2.14: Records of large floods in West Bengal and their effects on Kolkata
Source: Dartmouth flood observatory global archive

Records of large floods in West Bengal Period	Vulnerable Areas of Kolkata
1978: Sept. 4th-Sept 10th	Monsoon rains caused unprecedented damage and made millions of people homeless in large parts of Northern India. Some areas of the state of West Bengal were 18 feet (5.5 meters) below water.
1986: Sept. 24th-Oct 10th	Flooding from heavy rains in some areas of Kolkata, Hooghly, Howrah, Parganas and Midnapore
1999: Sept. 24th-Sept. 29th	Tropical cyclones caused destruction of an estimated 1500 villages. Floods due to brief torrential rains affected areas of Kolkata, Burdwan and Birbhum
2000: Sept. 18th–Oct. 21st	Late monsoon rains that triggered flash floods
2001: July 31st–Sept. 1st	Monsoonal rains caused flooding in Kolkata
2004: June 20th—Oct. 7th	Heavy monsoonal rains affected several districts
2006: Sept.18th—Oct. 5th	Monsoonal rains and tropical cyclone-driven storms in the Bay of Bengal hit India and Bangladesh. West Bengal recorded 50 deaths, 300 were injured and 30,000 mud houses were destroyed. Heavy rains left large parts of Kolkata under water; 2,000 people were subsequently

	evacuated from the city
2007: July 3rd—Sept. 22nd	The hazard affected Kolkata and several other districts. Eighty-three deaths were reported, and millions of people were marooned in 3000 villages in coastal areas of the state

Dhaka has an even longer history of major flooding than does Kolkata. However, during the initial years (1954, 1955, 1970, 1974, 1980, 1987) until about 1987, much of the flooding was caused primarily by overflow of its surrounding rivers, as the city was not yet that densely developed and drainage congestion at that time was therefore less of an issue. The floods of 1988, 1998, and 2004 were some of the most damaging to the city, where large parts of the most vulnerable southern and western areas of the city were devastated. Among these, the 1988 floods which hit Dhaka was the most severe; about 85% of the city was inundated, with water levels ranging from 0.3-4.5m (levels above 0.25m are considered life-threatening) affecting almost 60% of the city residents. The flood in 1998, though slightly less damaging than the one in 1988, still affected about 56% of the population with the city under flood water for over 69 days. The 1998 floods were somewhat of a turning point–spurring further flood management measures—as even some of the "protected areas" were inundated (Alam and Rabbani 2007; Yahya et al, 2007; ICEAB, 2010)

The frequency and severity of flooding in Kolkata has increased markedly over the past two decades as well; significant inundations are now a frequent event. Sudden, intense rainfall at the end of the monsoon season is now contributing significantly to flash urban flooding. 1500 lives were lost in the record floods in 2000, and the floods of 2007, 2008 and 2009 each resulted in hundreds of deaths and in the dislocation of hundreds of thousands of mostly poorer residents.

The findings on the variability of rainfall characterized by intense periods of precipitation concentrated in a few months of the year, is further validated by the IPCC 2007, which also speaks to this recent increase in floods and deluges in South Asia. Based several studies and corroborative data (Lal, 2001, 2003; India Meteorological Department, 2007; Dartmouth Flood Observatory, 2003), IPCC (2007) finds that since the 1970s, precipitation "intensity is increasing causing severe floods in terms of damage to life and property" in coastal regions of India and Bangladesh. Moreover in the "Regional Climate Projections" IPCC 2007, the projections on moisture-related phenomenon further corroborate the climatic patterns now evident in Kolkata and Dhaka. In terms of extreme precipitation events, the IPPC notes that it is "very likely" that there will be a "large increase during the Indian summer monsoon season over Arabian Sea, tropical Indian Ocean, South Asia[25]" (Rupa Kumar et. al., 2006). IPCC also finds that it will be "likely" that wet days "will decrease in South Asia" Krishna Kumar et al. (2003) and dry spells "will increase in most sub-tropical areas"; Kolkata and Dhaka both fall within these sub-tropical climate zones (Christensen et. al., 2007).

Other Climatic Risks:
Cyclones and Storm Surges, Sea-level Rise and Salinity Intrusion, and Land Subsidence

Cyclones and Storm Surges

Though urban flooding is the most immediate and critical risk arising from climatic variability in the water sector, cyclones, storm surges, and sea-level rise, as well as land subsidence, will also have marked long-term effects, in addition to amplifying existing flood risk from intense rainfalls. According to Kelkar and Bhadwal (2007), in a scientific study conducted by the Indian National Commission in 2004, among all coastal states of India, "West Bengal [of which Kolkata is the capital] ranked first in terms of frequency of occurrence of cyclones". In fact, the entire coastal area of Bay of Bengal, where both cities are located, has a long history of intense cyclonic activity.

Of the almost 80 global tropical storms (tropical cyclones whose wind speeds are at least 17m/sec), about 6.5% originate in the North Indian Ocean (McBride 1995; Neumann 1993). However, the frequency of these cyclones that originate in the entire North Indian Ocean is about five to six times more in the Bay of Bengal (IMD, 1979). Moreover, of all the global tropical cyclones that inflict more than 5000 casualties, coastal Bangladesh is the most affected (sixteen out of every thirty-five), followed by eleven of every thirty-five for India. In fact, although only about 4% of all tropical cyclones affect the two countries, Bangladesh accounts for 53% of total deaths, followed by India at 23% (Ali, 1999). Some of the major cyclonic disasters to hit Bangladesh (and which also affected Dhaka) include those in 1985, 1988 and 1991; the latter claimed over 138,000 lives (Ali, 1999). In India, according to the archival data from the Indian Meteorological Department, 41 major cyclones originated in the

Bay of Bengal and made landfall on the eastern coast (where Kolkata is located) between 1970 and 1999, causing much devastation of property and loss of life.[44] In India in 2009, Cyclone Aila, a 1.2-year-return-period cyclone with an average wind speed of 95mph, caused 190 deaths, 7,103 injuries and affected 3.9 million people. The estimated damage of assets from Aila is $270 million (EMDAT-DAT, 2013). For Bangladesh, the corresponding figures from Aila include 237 deaths, over one million livestock killed, and 250,000 homes destroyed, while almost half a million others were severely damaged. Moreover, nearly 70,000 acres of crops were fully lost (with an additional 240,000 acres experiencing significant crop losses), over 250km of roads were rendered unusable, and 2500km of embankments were heavily damaged or obliterated (Mallick and Vogt, 2012).

Though such recent cyclones have caused much damage in the coastal part of Bay of Bengal even in recent years, the frequency of such cyclones have shown a decreasing trend since the 1970s (Lal 2001). However, though less frequent, these cyclones have clearly increased in intensity (PAGASA, 2001; ABI, 2005; GCOS, 2005a, b). Moreover, the rise in sea-surface temperatures (SST) has been linked conclusively to the genesis and intensification (increase in wind speed) of tropical cyclones (Miller, 1958; Ali, 1999; Wendland, 1977; Gray, 1979; Emanuel, 1987; 1988, and Saunders and Harris, 1997). Though we naturally cannot be absolutely certain that cyclone frequency in this region will increase, Knutson and Tuleya (2004) and Lal (2001) do project that with a rise in sea-surface temperature rise of 2-4°C, relative to current thresholds, tropical cyclone intensities will increase between 10 and 20% (Cruz et. al., 2007). Thus, irrespective of whether *more* cyclones will strike Kolkata and Dhaka, the growing *intensity* of future cyclonic events still leaves both cities at great risk.

Storm surges and cyclones are closely associated with each other. Both are caused by winds and changes in atmospheric pressure, but the height of storm surges is more directly related to the intensity of winds than to sea-level rise. Like cyclones, storm surges are also intensified by increases in the SST. In addition, flat land formations along the coast adjacent to the sea and regular high tides also contribute to the amplification of storm surges (Ali, 1999).

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[44] (For a list of these cyclones that have affected Kolkata, please see http://www.imd.gov.in/section/nhac/static/cyclone-history-bb.htm).

TABLE 2.15: Storm Surge heights (m) under different sea surface temperature and sea level rise scenarios; a wind speed of 225km/hour corresponds to that of the April 1991 cyclone
Source: Ali 1996

Return Period (year)	Current sea-surface temp. (27°C)	2°C increase	4°C Increase
Wind Speed (km/h)	225	248	278
Change in sea level	Surge Height in m (% change)		
Sea level rise=0.0m	7.6 (0%)	9.2 (21%)	11.3 (49%)
Sea level rise=0.3m	7.4 (-3%)	9.1 (20%)	11.1 (46%)
Sea level rise=1.0m	7.1 (-7%)	8.6 (13%)	10.6 (40%)

In his study of the effects of the rise in sea level and sea-surface temperatures, Ali (1996) finds that both these factors directly relate to the height of storm surges. These estimates were clearly in keeping with the observational data from the April 1991 storm surge and cyclone that affected Bangladesh.

Though there is no conclusive data to suggest that the frequency and intensity of storm surges will increase in the urban areas of Dhaka and Kolkata, rise in sea level and surface temperatures along the coast over longer periods of time may eventually affect these cities directly through cyclones and storm surges. In Kolkata, since it is located about 120km from the open sea, storm surges are not as frequent and are limited mostly to the lagoon areas of the river Hooghly. In Dhaka, it is again the tidal surges of its adjacent rivers that cause flooding, rather than storm surges affecting the city directly. However, in Bangladesh storm surges that are over 10m are not unusual along the coast (Ali, 1999). In Dhaka, storm surges in 1970 and 1991 killed over 650,000 and displaced tens of millions; future episodes could be still more devastating.

Climatic models, however, do predict a progressive increase of storm surge height of up to 9.2m, when assessed in 10-, 25-, 50-, and 100-year periods, which will also be accompanied by dramatic increases in wind speeds, which range from 167km/h in the 10-year period to about 231km/h in the 100-year period.

TABLE 2.16: Maximum storm surge for various return periods for the average coastal length of West Bengal
Source: Dasgupta et al., 2012

Return Period (year)	10	25	50	100
Maximum Wind Speed (km/h)	167	195	215	231
Maximum Storm Surge Height (m)	4.5	6.3	7.8	9.2

Though storm surges are presently uncommon in Kolkata and Dhaka proper, and the associated risk is not an immediate issue, the highest tidal wave ever to hit the Kolkata area was about 6m (Dube et.al 1997), while a surge of 3-4m has been observed a few times in both urban areas. However, if the cities experience intense rainfall coinciding with high tides and an extreme storm surge, the cumulative effects for areas that are already vulnerable to floods can be devastating.

Sea-Level Rise and Salinity Intrusion

Global warming is also resulting in higher sea levels, another environmental and disaster-risk factor for both Kolkata and Dhaka. In the last 20 years, Kolkata's temperature[45] has spiked considerably in part due to global climate change, where between 1981 and 2001, the average

[45] According to the Köppen climate classification, Kolkata has a tropical wet-and-dry climate, with an annual mean temperature of 26.8°C (80°F) and monthly means between 19° and 30°C. Kolkata summers are hot and humid, with average daily summer temperatures ranging from the low 30s to above 40°C, peaking in the low 40s in May and June (Kolkata Municipal Corporation, 2012). The winter months are relatively mild, with a seasonal range of 12°C – 14°C (54°F – 57°F), with lows principally in the months of December and January. The highest daily temperature on record is 44°C (113° F), with the lowest at 5°C (41°F). The Köppen climate classification, which dates originally from 1884, remains a standard for the field. The Köppen classification utilizes average monthly and annual precipitation and temperature statistics, but draws primarily upon vegetation patterns to establish climatic zones (McKnight and Hess, 2000).

The city of Dhaka has a hot, humid tropical climate with a distinct monsoon season. Under the Köppen classification, it is categorized as having a tropical wet and dry climate. With an annual average temperature of 27.5ºC (81.5ºF), Dhaka has monthly mean temperatures that peak at 36ºC (97ºF) in April and drop to 14ºC (57ºF) in January. In the heat wave that struck Bangladesh in 2009, the national Meteorological Office recorded a temperature of 39ºC (102ºF). Weather trends show that the average temperature in Dhaka increased by about 0.75ºC between 1985 and 1998.

temperature for Kolkata rose by almost 1°C. According to Dasgupta et al. (2012), Kolkata's temperatures will continue to rise, thereby continuing to affect sea levels; the authors estimate that, by 2050, temperatures will increase further by 1.8°C and 1.2°C for the A1F1 and B1 scenarios, respectively. In Bangladesh too, this warming trend is currently affecting sea level rise as well. Kabir and Faisal (2006), utilizing Geophysical Fluid Dynamics Laboratory (GFDL) projections, predict that, by conservative estimates, temperatures in Bangladesh (relative to 1990) will rise by an average of 1°C and 1.5°C in 2030 and 2050, respectively. In Dhaka, this warming trend is likely to continue; analysis of temperature data of Dhaka for 54 years (starting in 1954) finds that temperatures in the city have increased by an average of 1.72 ^{0}C per 100 year (Islam, 2009).

Kelkar and Bhadwal (2007), in their study on the vulnerability of coastal districts in India to sea-level rise, incorporating social and population factors, found that between 1920 and 1999, the coast of West Bengal, where Kolkata is located, was the most vulnerable area, along with the Gulf of Kutch on the west coast. The researchers also concluded that, under the influence of climate change, the sea along this entire coast is expected to rise 10-25cm over 100 years. Dasgupta et al. (2012) use higher estimates in their calculations, predicting a sea-level rise of about 27cm by 2050,[46] which they nonetheless consider a conservative figure. A more sobering study from the World Bank (2000), which simultaneously takes delta subsidence and sea-level rise into account, the overall change in sea level will be 30cm by 2030 and 50cm by 2050. Despite these somewhat varying estimates of sea-level rise, the fact remains that both Kolkata and Dhaka will be directly or indirectly affected. Sea-level rise will reduce agricultural productivity along the coast of the Bay of Bengal through actual loss of land as well as salt-water intrusion. This may create issues of food security for these cities and also further damage the mangroves, which act as a natural buffer for storms and cyclones while supporting the balance of bio-diversity along the coasts.

Another disturbing impact of sea-level rise is its role in prolonging the duration of flooding. Since the Ganges-Brahmaputra-Meghna system's

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[46] The definitive study of temperature rise for the region, commissioned by the World Bank with support by the West Bengal government predicts a sea-level rise of 27cm by 2050 (World Bank 2011). Also see http://climatechange.worldbank.org/content/bangladesh-economics-adaptation-climate-change-study

confluence comes at only 50km from the Bay of Bengal, rising sea levels will create a strong "backwater effect", preventing the three rivers from draining effectively into the sea and thus extending the periods of inundation (Kabir and Faisal, 2006). Moreover, with each coastal storm surge and gradual sea-level rise, salt water pushes further inland to mix with the freshwater rivers that criss-cross the delta region.

This salt-water intrusion caused by sea-level rise and storm surges will ultimately affect the very large adjacent rivers that serve as a source of fresh water for the cities. Many Asian coastal mega-cities have been found to be prone to salt-water intrusion; among these, Kolkata has been found to be the most vulnerable (WWF, 2009). In their study, "Saline Water Contamination of the Aquifer Zones of East Kolkata", Saha and Choudhury (2005) found that "there are sub-surface saline/brackish water zones" in the groundwater of the south and southeastern parts of Kolkata. Their results indicate that saline contamination of the groundwater ranged from shallow subsurface levels up to a depth of 50 meters in some places. They also conclude that continued high levels of freshwater extraction will increase the salinity of aquifer water through downward percolation of brackish water. The authors also note that the fluid dynamics of the southern and southeastern parts of the city greatly increase the vulnerability of the water supply of these areas.

Although no studies have yet found similar salt-water intrusion in Dhaka city, Zahid and Ahmed (2006) do attribute saltwater intrusion to high rates of groundwater extraction, particularly in shallow, unconfined aquifers; heavy extraction also causes raised levels of arsenic concentration and further drops in water quality. Their research also shows that that the aquifers of Khulna city have already been contaminated by saltwater intrusion. Dhaka city, which is only about 80 miles from Khulna, thus remains vulnerable to salinity intrusion as well.

The fact that saltwater contamination has already begun to occur in the groundwater of Kolkata, and in urban centers near Dhaka, poses some serious problems in terms of water supply for the cities, since a major share of their piped water supply comes from groundwater. Although the KMC has sought to decrease reliance on groundwater by utilizing more surface treatment plants, intensifying private drilling more than offsets the diminished public groundwater extraction (KMC, 2007). Dhaka likewise relies almost exclusively on groundwater for human consumption and agriculture. Moreover the possibility of saltwater contamination of the cities' rivers from long-term sea-level rise also complicates the situation further, contaminating fresh-water supplies of the city. This situation poses an even greater urgency to preserve the urban wetlands, not only to temper urban micro-climates and control floods, but also to maintain groundwater recharge zones and avoid excess runoff. Additionally saltwater intrusion, predicted to reach over sixty miles inland by mid-century, not only threatens the massive mangrove forests that now partially insulate Bangladesh's coast from storm surges, but may also reduce grain production by up to a third of current levels and severely curtail yields from fishing and aquaculture (Rahman, Majumder, Rahman, and Halim, 2011).

Land Subsidence

As discussed previously, Kolkata and Dhaka are already experiencing heightened risks from climatic factors in the form of above-average rates of sea-level rise, salinity intrusion, cyclonic activity, storm surges and flooding. These risks are further aggravated by reduced sedimentation caused by upstream dams, coastal erosion, depletion of the mangrove forests that protect the coast from cyclonic damage, and considerable land subsidence. Moreover, many of these factors work in mutually reinforcing ways. The excessive groundwater extraction in both cities lowers the water table, thus also contributing to land subsidence while increasing pumping costs and rendering existing wells useless (Milliman et. al., 1989; Zahid and Ahmed, 2006).

Kolkata has already experienced high rates of subsidence, ranging from 6.5-13 mm annually over the past fifty years or so (Chatterjee et al. 2006). If such rates of subsidence continue unabated, the dangers of climate-related flooding in Kolkata proper and the broader KMA will increase exponentially (OECD, 2007). Though there are very few dedicated studies on the rate of subsidence[47] in Dhaka, well logs taken from the northwest of Dhaka indicate that parts of the basin are experiencing a subsidence of 2.2 cm/year, whereas in Dhaka city, the average subsidence is estimated at about 0.62mm/year (Alam 1996). Huq, Ali, and Rahman (1995) note that of the areas experiencing considerable subsidence in Bangladesh, the rate of subsidence in Chalan Beel, the

[47]Although the exact extent of subsidence is unknown, the coast of Bangladesh, like other delta regions is highly vulnerable to subsidence (Morgan and McIntyre, 1959; Milliman et al., 1989).

Dhaka Depression, and Khulna Sunderbans ranges from 0.6mm/year to 5.5m/year while in the Surma Basin it is more than 20mm/year.

In urban areas like Kolkata and Dhaka, subsidence creates additional risks for three primary reasons. First, the cities are expanding into their wetlands, creating an unstable foundation for construction of buildings. In an area where the soil is already easily compressible, construction in densely developed areas becomes further prone to collapse. Second, land subsidence also creates depressions where floodwaters easily accumulate. Third, land subsidence in earthquake-prone areas like Dhaka[48] and, to a lesser extent, Kolkata,[49] a risk compounded by inadequate drainage, heavy sedimentation, and recurrent tidal surges, causes substantial coastal erosion and land loss.

Discussion

The increase of temperatures in South Asia is hastening the process of climate change in many ways. The effects of these changes, particularly those that directly or indirectly relate to the water sector, can manifest themselves in a number of ways, including glacier retreats, erratic precipitation trends, and increased water runoffs. These climatic changes have far-reaching consequences for urban areas in the region, ranging from diminished availability and quality of fresh water to curtailed food production, Moreover, urban ecosystems, such as wetlands, that have the potential to ameliorate some of these urban risks are also deteriorating, raising the likelihood of extreme climatic events and long-term hazards. Both Kolkata and Dhaka, like many other urban centers in this region, are facing these same threats. Not all of these climate related changes can be addressed at the local level, however. Complex, interrelated climatic

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[48] Though Dhaka city does not display any signs of surface folding, there are many faults and lineaments running along the city, both north-south and east-west. The city itself is also surrounded by four major faults. The city of Dhaka is located in seismic Zone 2 according to (The *Bangladesh National Building Code* 1993). The problem of soil liquefaction leading to increased vulnerability to earthquakes has become even more serious with the unregulated urban growth and population increase. The rising demand for new construction to support the population has been met to a large extent by filling lowlands, swamps, and wetlands with dredge materials, an approach that substantially weakens the bearing capacity of the soil (Islam, 2010).

[49] Parvez, Vaccari, and Panza (2003) identify Kolkata, which lies within India's design ground acceleration (DGA) zone, as a city at significant earthquake risk, though less so than Delhi.

impacts such as glacier melting, increased water runoffs, and rising temperatures—which affect the entire region—need regional and global cooperation and collaborative management.

So the questions then become, first, what can city-level agencies do to adapt to these increasingly serious urban risks? And, second, equally important, how should these agencies prioritize local adaptation efforts? Given the resource constraints of cities like Kolkata and Dhaka, as discussed in chapter 1, addressing all these problems at one time is not practically feasible. Hence, a risk assessment for these cities provides a roadmap to understanding the most critical effects of climate change as well as the non-climatic factors that in reinforce and exacerbate these risks.

The geographic location of Kolkata and Dhaka on a sensitive coastline, along with their topographical susceptibilities, including numerous rivers and swampy marshlands, makes them already vulnerable to climate change at the onset. Additionally, several non-climatic factors—among them population growth and density, poverty, and poor drainage, sewerage, and water infrastructures—have cumulative effects. Moreover, while these cities are particularly prone to salinity intrusion, land subsidence, and exposure to extreme weather events like floods and cyclones in the near term, climate change brings additional threats, including the spread of catastrophic epidemic diseases during severe climatic events.[50] *The additive, mutually reinforcing nature of these risks arising from climate change makes the situation for Dhaka and Kolkata especially critical and climate adaptation an absolutely necessity. Inaction ultimately requires greater resources than does systematically identifying and addressing risks, as the costs of climate change—from degraded quality of life to economic devastation—increase. (Dickson et. al., 2012).*

The risk assessment of these cities illustrates planning options that, if prioritized and addressed in the near term, will go a long way towards curbing climate-related vulnerabilities. Adaptation efforts focusing on the water sector can be just such a strategic intervention, one that has not

[50] Since the impacts of climate change on vector- and water-borne diseases are necessarily difficult to quantify, but potentially catastrophic, considering the potential benefits of climate adaptation for public health is essential, but problematic, because "compared with more traditional risk factors, actions to mitigate or adapt to climate change affect human health through a much wider variety of mechanisms and over much longer periods" (Campbell-Lendrum, D., and Woodruff, R., 2006).

only immediate adaptive and developmental benefits, but also long-term implications for enhancing resilience. Key among these strategic interventions may include water management through infrastructural, policy-oriented and institutional reform measures, offering the ability to provide steady, safe, and uncontaminated fresh water supply (from surface sources) even if climate change intensifies. Other strategic adaptations could include preservation and protection of urban eco-systems coupled with drainage infrastructure enhancements. Such measures not only represent less resource-intensive options to decrease flood risks, but also provide groundwater recharge zones and reduce runoff and saline contamination while counteracting heat-island effects. Water management, urban ecosystems, and drainage infrastructure are three elements of climate adaptation thus suited to the specific contextual challenges and threats of the South Asian region.

3

EVALUATING APPROACHES TO ADAPTATION IN THE CONTEXT OF SOUTH ASIAN MEGA-CITIES

"Now we must learn to live in the real world".
George Monbiot[1]

THE EMERGENCE OF ADAPTATION

Adaptation as a policy response has gained considerable traction only in the past decade, resulting largely from the growing realization that mitigation has proven insufficient to avert the risks of a changing climate (Sarkar, 2011). Though not as central to the climate-change agenda as mitigation was, there were some early indications that adaptation needed to be taken seriously not only because it was a "powerful option" to combat climate change effectively, but also because climate change had already begun to occur in many parts of the world (IPCC, 2007).

As early as the mid-1990s, several influential scientific institutions, including the Stern Review (Stern, 2005) and IPCC, had lent credence to the adaptation discourse, endorsing it as a viable policy option, one that was justified and necessary based on the growing body of scientific evidence.

In the political arena too, adaptation rose to the forefront soon after, with the establishment of several international initiatives. Once the Marrakech Accord[2] to clarify the Kyoto Protocol was ratified, several other programs, including the National Adaptation Programme of Action, the Kyoto Protocol Adaptation Fund, the Least Developed Countries Fund, the Strategic Priority on Adaptation, and the Special Climate Change Fund were also initiated.[3] Among this wave of international agreements, the

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[1] Published in the Guardian 14th, October, 2008
Please see http://www.monbiot.com/2008/10/14/this-is-what-denial-does/

[2] The detailed rules for the implementation of the Kyoto Protocol (widely known as the Marrakesh Accords) were adopted at COP 7 in Marrakesh in 2001.

[3] Some of the different Climate Change Fund programs and grants established to support adaptation, especially among least developed and developing nations, include:

Delhi Declaration in 2002 (Delhi Declaration UNFCCC, 2002) also resulted from an emerging awareness among resource-constrained developing nations that a coordinated international response was paramount for adaptation to climatic change.

Meanwhile, mitigation has not been enforceable to the degree necessary to avert the consequences of climate change; the contested political space surrounding the climate negotiations caused these negotiations to falter[4].

- *National Adaptation Programmes of Action (NAPAs):* These allow LDCs to more easily target and prioritize their climate-change adaptation agendas, especially with regard to cost factors and the effective time horizons of potential projects. Thirty-nine NAPAs have been received since December 2008.
- *The Adaptation Fund:* This is an international fund set up under the Kyoto Protocol (UNFCC) that provides resources intended to enable developing countries to combat the deleterious impacts of global warming.
- *The Least Developed Countries Fund (LDCF):* This is a fund that assists Least Developed Country agencies (LDCs) in preparing and implementing their NAPAs.
- Strategic Priority on Adaptation (SPA): Established by the Global Environment Facility (GEF) in 2004, the SPA, which had an initial allocation of $50 million, with another $649 million obtained in co-financing, supports pilot and demonstration adaptation projects that can be incorporated into national policies and sustainable development planning in eligible nations.
- *The Special Climate Change Fund (SCCF)*: This fund, established by the Global Environment Facility (GEF) in 2000, complements other UNFCC funds and finances projects which focus on adaptation, technology transfer and capacity building, energy, transport, industry, agriculture, forestry, waste management, and economic diversification.

[4] The United Nations Framework Convention on Climate Change (UNFCC) established the Kyoto Protocol in February 2005, which was signed by 37 industrialized nations and the European Community and set binding targets to reduce GHG emissions between 2008-2012 by 5% against 1990 levels. The fact that the Protocol sets out more stringent standards for developed nations has caused polarization between developed and developing nations; as a result, some developed countries, such as the US and Australia, have yet to sign on. Moreover, India and China, two of the heaviest absolute and per capita polluters among developing countries, have been granted a certain degree of leniency in meeting their respective targets. Many of the countries that have signed the Protocol will likely not be able to achieve the necessary reductions within the 2012 timeframe; these nations will compensate for this shortfall by purchasing carbon credits or investing in green technologies in non-Annex 1 countries, a situation that will lead to many additional gray areas of enforcement and monitoring. There are efforts to include other supporting mechanisms, including the Clean Development Mechanisms and Joint Implementation, to further climate—change agenda via this forum.

The reality is that even if mitigation were entirely effective, it would not reduce the increasing risks associated with sudden climate change for at least the next 50 years. Given the extent to which we are already facing climate change, adaptation is no longer a policy choice or option – it has become an absolute necessity (Susskind, 2010).

Thus, as "adaptation" is increasingly being viewed as a necessity, it is becoming an integral component of the international climate-change vocabulary, researchers, practitioners, governments, and NGOs are developing varied perspectives on the definition (Smit et al., 2000), nature, and, more important, approaches to adaptation in order to enable effective implementation (Schipper, 2009) across different scales (Bulkley and Betsill, 2007) and environments (Huq, Kovats, Reid, and Satterthwaite, 2007).

DEFINING ADAPTATION

The concept of adaptation has been important for millennia (Smithers and Smit, 1997); availing new opportunities and reducing adverse environmental consequences have been central throughout human history. However, adaptation as a "theory" gained broad scientific credence following Charles Darwin's explication of biological adaptation in *The Origin of Species*, 1859.

Consequently, adaptation has been examined through many lenses and by many disciplines and the term has been explored beyond mere biological adaptation; social, economic, and cultural adaptation processes have been embraced by many different disciplines such as anthropology, archeology, biology, ecology, geography, political ecology, psychology, and global environmental change science (Schipper 2007; Janssen et al., 2006; Bock, 1980; Butzer, 1980; Alland, 1975).

Within the context of societal development, adaptation has the ability to address not only environmental unpredictability, but also disturbances in social, economic and political spaces. (Schipper, 2007; Pelling, 2003). What makes climate-change adaptation especially compelling and complex, however, is the range of factors—including energy needs, agriculture, water use, littoral and inland ecosystems, and industrial development, to name but a few—that must be considered in order to arrive at policies and establish projects that offer some chance of success in the face of imperfect information and uncertain future developments

(Adger et al., 2003). Moreover, the effects of climate change extend far beyond environmental concerns to include political, socio-economic, cultural, and population consequences (Pittock and Jones, 2000). For cities and regions to adapt to a wide range of possible climate change risks—in other words, to reduce their vulnerability and increase resilience—Susskind (2010) provides a useful way to think about adaption in terms of risk management.

The IPCC offers a broad definition for climate adaption that serves as an elemental foundation, where adaptation is defined as an "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC 2007).

Some other useful definitions from the social scientific spectrum of adaptation literature, as listed by Smit et al 2000, include:

*"Adaptation to climate is the process through which people **reduce the adverse effects** of climate on their health and well-being, and take advantage of opportunities that their climatic environment provides"* (Burton 1992).

*"Adaptation involves **adjustments to enhance the viability of social and economic activities** and to **reduce their vulnerability to climate**, including its current variability and extreme events as well as longer term climate change"* (Smit, 1993).

*"The term adaptation means any adjustment, whether passive, **reactive or anticipatory** that is proposed as a means for **ameliorating the anticipated adverse consequences** associated with climate change"* (Stakhiv, 1993).

*"Adaptation to climate change includes **all adjustments** in behavior or economic structure that **reduce the vulnerability of society** to changes in the climate system"* (Smit et al., 1996).

*"Adaptability refers to the **degree to which adjustments are possible** in practices, processes or structures of systems to projected or actual changes of climate. Adaptation can be spontaneous or planned, and can be carried out **in response to or in anticipation of change in conditions"*** (Watson et al., 1996).

(Emphasis added for quotes above).

While all these definitions are thematically linked to the IPCC definition, each one highlights different, but not dissimilar, aspects of the nature of adaptation. Almost all defintions speak to some extent about vulnerability reduction, adjustments made in (human) systems, and ameliorating adverse consequences for immediate and long-term effects. Of course, all speak of adapting to conditions that are a *direct result of climate change*. This is where I make a slight departure from the standard set of definitions found in the literature. In researching the adaptation efforts in Kolkata and Dhaka, I have found that "formal" adaptation plans, especially at the city level, are few and far between, and "exclusive" adaptation measures are generally limted to emergency response strategies. Instead, there are a range of developmental planning efforts that contain adaptive benefits, including reducing overall vulnerabilty and ameliorating adverse circumstances (both in the short and long-term). Although most of these measures are not primarily initiated as climate adaptation efforts, the measures do have significant ancillary adaptation benefits.

Therefore, a starting point for a working definition of adaptation—in the context of South Asian mega-cities—could read as follows:

> *Adaptation is pathway for **incrementally** enhancing resillience and thereby ultimately reducing climate risk, through measures that have the ability to **be easily incorporated into the existing planning agendas**, in order to overcome resource constraints, institutional barriers and increase the likelihood of their implementation.*

The key points of departure in this process-oriented definition are that adaptation planning in South Asia will most likely have to be "incremental" in nature to succeed, and, that in order to increase the likelihood of implementation, such efforts should have the ability to be "easily incorporated into [ongoing] planning efforts". Given the severity of resource constraints, the likelihood of dedicated adaptation planning gaining momentum in the current scenario seems highly unlikely. Nevertheless, incremental efforts have the ability to increase resillience and reduce climate risks in the interim while requiring less upfront investment and expertise. Moreover, such incremental efforts, when incorporated into existing planning agendas, have a higher likelihood of success than do stand-alone adaptation approaches that would need to be designed and implemented from scratch.

THE LANDSCAPE OF ADAPTATION

Within the many dimensions of adaptation classifications, climate researchers have distinguished different *types* of climate-adaptation planning on the basis of a range of different factors. For example, in their seminal paper "An Anatomy of Adaptation to Climate Change and Variability", Smith et al. (2000) differentiate among four commonly accepted typologies of the nature of adaptation based on key descriptive attributes (B. Smith, Burton, Klein, and Wandel 2000; Malik et al., 2010). These attributes are: *Intent/purposefulness* (Autonomous, Planned); *Agents* (Private, Public); *Timing* of Adaptation Action (Anticipatory, Reactive, Concurrent); and *Temporal Scope* (Short-Term/Tactical, Long-Term/Strategic). In addition to these broader classifications, the *Spatial Scope* (e.g., local versus regional) and the various *Forms* of adaptation (e.g., technological, behavioral, and financial) are also used to classify types of climate-adaptation planning in the literature (cites). [5]

The most widely applied concepts within these types of adaptation are the distinctions between *planned* and *autonomous* adaptation, "identified by the intent or level of purposefulness of adaptations" (Smith, Burton, Klein, and Wandel, 2000; Smith and Lenhart, 1996; Carter et al., 1996).

Planned adaptations, as characterized by much of the literature, are generally anticipatory actions (those undertaken to mitigate some anticipated impact of a climate risk) and involve deliberate intervention.[6] Establishing early heat-wave alarm systems in cities when prompted by earlier heat waves or anticipated ones, "based on an awareness that conditions are about to change or have changed and that action is

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[5] Also see Smit et al., 2000 and Smit and Wandel, 2006 for two additional "anatomies" of adaptation options that draw upon a broad survey of the current climate-change research based on a range of factors, including scale; scope; events and actors that enable adaptation; the ultimate goals of the approach; and the nature of these processes.

[6] Brooks (2003) also notes that planned adaptation measures, especially those undertaken by governmental agencies, depend not only on the effective cooperation of various stakeholders and authorities, including civic groups, industry, and multiple levels of government, but also on the society's economic structures, financial resources, and the performance of state institutions.

required to minimize losses or benefit from opportunities" (Pittock and Jones, 2000), represents an illustrative example for *planned* adaptation.

In contrast, *Autonomous* adaptation[7] refers to responses to changing conditions undertaken by private actors (individuals or communities) or those that are "natural or spontaneous adjustments in the face of a changing climate" (Carter et al., 1994). This type of adaptation is generally *reactive* in nature; the responses are initiated *spontaneously* in the face of immediate perceived threats. An example of *autonomous* adaptation that is also *reactive* would be the temporary migration or displacement of communities or individuals, for instance, in the event of a sudden flood.

Within this adaptation continuum, Frankhauser et al., (1999) describe the relationships between autonomous (generally reactive in nature and often spontaneous) and planned (typically anticipatory) adaptation as that of complements or substitutes, wherein one type of adaptation may increase the benefit of the other. Along the same lines, Stakhiv (1996) posits that there maybe instantaneous and cumulative benefits from the integration of these two types of adaptation.

An interesting example from rural Bangladesh that illustrates these complements and/or substitutes,[8] as well as cumulative benefits, can be found in the case of adaptation to frequent flooding. Farmers in rural areas have been creating "high ledges" within their dwellings, in which they store their valuable belongings safely, as a spontaneous, reactive response to frequent flooding. This autonomous adaptive behavior of the farmers sometimes obviates the need for anticipatory adaptations on the part of governmental agencies, or substantially reduces the cost of adaptive efforts, as fewer and smaller shelters are subsequently required. To enlarge upon these autonomous measures, the Government of Bangladesh has created shelters on stilts in many villages to establish

[7] As defined by the IPCC, autonomous adaptation is a situation in which "adaptation does not constitute a conscious response to climatic stimuli, but is triggered by ecological changes in natural systems and by market or welfare changes in human systems." It is also referred to as spontaneous adaptation (IPCC, 2001).

[8] Frankhauser et al. (1999) make a very useful distinction between substitutes and complements in the context of climate change adaptation. Substitute anticipatory/planned adaptations make subsequent reactive or autonomous ones unnecessary, while complementary anticipatory adaptations can augment reactive ones and thus "can be used to leverage the scope for subsequent reactive action".

flood-proof enclosures for livestock, farm equipment, and vehicles.[9] The synergies between the deployment of these public shelters by the government (planned adaptation) and the construction of ledges by farmers (autonomous adaptation) in effect reduce the logistical difficulties associated with constructing a number of different types of shelters (for livestock or belongings), while limiting the net costs borne by either party. These complementary adaptations provide shelter for villagers who enjoy access to the government-constructed ones, while the government is freed of the additional burden of having to build safe areas for personal belongings. Each type of adaptation benefits from the utilization of the other; the overall adaptive benefits are substantially augmented in the process.

In cities, however, autonomous adaptations have less relevance than do planned adaptations. Autonomous adaptation works best in rural areas where the residents bear the direct cost of climatic consequences with greater frequency, and moreover are not privy to the benefits and resources generally associated with urban living, including comprehensive infrastructure, medical and emergency services, and technical expertise. For instance, subsistence farmers in rural Bangladesh, especially those along the mangrove coastline, live with the constant threat of the flooding of their farmlands and consequent loss of livelihoods, property, and occasionally, life. As a result, in the absence of timely and planned adaptations by the government, some of these farmers have adapted autonomously to such conditions by building embankments and protective walls every season to safeguard their crops, actions that have been extremely beneficial in avoiding or curtailing some of the immediate harmful impacts of climate change.

Although in rural areas such autonomous measures have significantly reduced climate risk, in cities, autonomous adaptations are generally less successful and at times can even be *maladaptive*. One such instance of maladaptive autonomous adaptation is where many residents in Kolkata have paved over or filled up many of the urban water bodies and channels, in order to counter the spread of diseases and germs associated with stagnant water and prevent overflow during high seasonal rains. However, in the process the natural drainage channels have been destroyed. Had these adaptations been "planned", however, governmental

[9] Similarly, in many instances, where shelters on stilts are not feasible, the government designates parts of existing highways that are built above the floodline for farmers to move their cattle to protect against floods.

authorities could have utilized their greater resources and expertise to preserve the urban water bodies and use them as natural reservoirs or water catchment areas during floods. Typically, such autonomous actions offer only temporary and partial fixes at best. They can actually discourage the broad systemic changes required for long-term sustainability, as autonomous efforts shift the responsibility away from the local agencies. The temporary fixes already in place allow municipal authorities to delay long-term measures to remedy the situation systemically. The cases of both partial adaptations, in which the entire range of benefits from an intervention is not realized (as described above in case of the natural drainage channels) and maladaptations, which can emerge from autonomous adaptations in urban areas, argue against autonomous adaptations in cities. Planned adaptations should therefore be prioritized wherever possible before private interventions are made. Planned adaptations provide an opportunity to not only assess the threats more comprehensively, but also choose options for adaptation that address multiple concerns simultaneously.

The issues of scalability, replicability, and codification likewise limit the long-term efficacy of urban autonomous adaptations. For instance, in the event of severe flash flooding within the city of Dhaka, many of the residents and NGOs create their own emergency systems to mitigate the loss of lives and property because the municipal governments lack sufficient capacity to respond adequately. These "informal" measures include boat ferry services to transport people to safer areas and creation of temporary food banks and dispensing stations for necessary provisions. Unfortunately, however, these informal, reactive adaptive actions are never institutionalized, leaving such actions subject to, year after year, upon the availability of private resources and the commitment of the residents to autonomous action. Moreover, since these adaptations are not part of the emergency response system of the city, they are neither scaled nor replicated to make them more efficient or equitable. Finally, no governmental resources are allocated to enable these responses to become a viable complement to the larger adaptation framework.

One near-ubiquitous barrier to effective climate-change preparedness in the developing world is the lack of resources and capacity; these deficits significantly hinder the implementation of an optimal, planned adaptation process. The financial limitations and the scale of challenges to be overcome, compounded by the effects of rapid urbanization, all speak to the "practical limits" outlined by Fussel (2007).[10] Moreover, even the plans intended primarily for development but that entail certain adaptive benefits do not always work well in practice as the options chosen are often constrained by the resources and technical expertise that are available. Moreover, most of these actions, though planned, are essentially "reactive" in nature to a great extent, often leading to "maladaptive" development alternatives (Burton, 1997) in the interim. An example is seen in the cheaper types of urban stormwater-drainage systems that are most commonly used in the developing world, without considering the long-term adaptive capacity of the systems. These systems are almost always "combined" types that carry both waste water and storm water and as a result often overflow and cause contamination and urban flooding during heavy rains in the city. Resource-constrained local municipalities, especially in cities of the developing world, thus need to evaluate their existing options on the basis of the *costliness*, *effectiveness,* and *implementability* of the adaptation options to prioritize long-term planning efforts (Smith, Burton, Klein, and Wandel, 2000).

Another central barrier to such wide-reaching adaptive planning remains because of incomplete information; local authorities possess little awareness of suitable adaptive measures and fail to exchange knowledge of best practices. The unwillingness of individual municipalities and national public agencies to identify and pursue opportunities for collaborative adaptation measures further hampers reduction of risk. Such structural, procedural, political, and institutional barriers also in effect hamper the implementation of comprehensive solutions and of collaboration across governing bodies throughout the Global South.

These classifications for the types of adaptations, such as planned and autonomous, are useful to the extent that they help frame the issues theoretically. In practice, however, these academic delineations often not only prove arbitrary and imprecise, but also overlap considerably. For example, in some cases, the process of adaptation may be initiated by private actors, but scaled up or codified (e.g., via regulations) by

[10] *Practical Limits* to adaptation, prevalent in many developing nations, can include insufficient resources, capacity deficits, and lack of political will. Fussel et al. also speak of the *Fundamental Limits* to adaptation, found in cases of irreversible destruction of ecosystems, such as the melting of Arctic glaciers, for which only mitigation measures offer the possibility of redress. Such *fundamental* and *practical* limits are rife in the South Asian context, and as a result many of the criteria for planned adaptation outlined by Fussel et al. are largely unmet across much of the Global South.

governmental agents; in others, planned adaptations can be either anticipatory or reactive. The categories thus fail to account well for the reality of adaptation planning and action in South Asia.

Moreover, while the "types of adaptation" are well defined and elaborated upon in the research on climate-change (Klein, 2003; O'Riordan and Jordan, 1999; Callaway, 2004; Adger et al., 2007; Hitz and Smith 2004a; Smith and Lenhart 1996b; Schipper 2007), actual adaptation processes have received far less scholarly attention. This limited scholarship, primarily based on empirical research conducted on the adaptation processes employed on various scales, suggests that actual adaptation processes are generally *ad hoc,* sectorally differentiated, and incremental in nature. Adaptation in practice assumes multiple forms depending on the particular access to information, technology, capacity, nature of threats, and socio-economic condition of the region (Downing et al. 1996; Carmin, Roberts, and Anguelovski, 2009; Lankao, 2007; Jodha, 1991; Tanner et al. 2007; World Bank 2008; De Sherbinin, Schiller, and Pulsipher, 2007).

Apart from these isolated empirical findings, some more established models may have the potential to provide practical insights for climate-adaptation planning South Asia. These theories, which are analyzed in detail in the sections below, include the *no-regrets* approach, *transformational* adaptation, *adaptation* approach, *vulnerability reductions* approach and the *integration* of adaptation with mitigation or disaster risk management. To streamline the analysis, such that their applications could potentially be better suited to practice, I have categorized them under three headings 1) *processes of adaptation* (no-regrets, transformational); 2) *adaptation as development* (vulnerability reduction, adaptation approach); and 3) *integrated adaptation* (with mitigation or disaster risk management).

DISCUSSION OF ADAPTATION THEORIES

Grouped under the three categories outlined above, the potentially relevant approaches are explored in further detail in this section followed by a "discussion", in which I evaluate the applicability and explanatory capacity of each in the context of South Asia from the point of view of local planning bodies.

The Processes of Adaptation: No-regrets and Transformational approaches

"No-Regrets"

There are numerous and somewhat varied perspectives that incorporate elements of the no-regrets concept in different ways. Some scholars (Callaway 2004; Schipper, Cigaran, and Hedger, 2008; Heltberg, Siegel and Jorgensen 2009; Smith, Vogel and Cromwell, 2009) view no-regrets from an integrated management standpoint, in which broader sustainable development goals take priority, but these development measures may also address climate risks and reduce vulnerabilities. Another version of this concept reverses the "planning priorities", privileging adaptations to climate change as the primary driver, which in turn may accrue additional incremental developmental benefits (see Carter, 1996, who also terms this a "win-win" strategy). Yet others propose "no regrets" as a suitable approach when planning in the face of uncertainty, as in the case of climate adaptation, where one cannot base actions entirely on predictive climate models, given the limitations that inhere in even short-term ecological and climate forecasts (Smith, Vogel and Cromwell, 2009).

In a different vein, Smith and Lenhart (1996) and Smith (1997) use "no-regrets" not so much as a planning approach but as an evaluative criterion for adaptation, whereby the "benefits independent of climate change" are used to assess the potential efficacy of different options. If we thus follow Smith et al.'s view of a "no-regrets" action as simply one measure within a broader framework, rather than as a stand-alone adaptation process, then most types of planned adaptation processes, including integrated ones, in fact contain significant elements of "no-regrets", rendering its utility as a standard of judgment somewhat limited. Most planned adaptations address vulnerabilities and developmental goals, explicitly and implicitly, while an increasing number of development projects have ancillary benefits for climate adaptation and risk reduction.

However, no matter how it is framed in the literature, the understanding and incorporation of "no-regrets" offers an extremely relevant, "useful and appropriate option when there is lack of resources and/or clarity in climate adaptation planning" (Callaway, 2004). Callaway's proposition, which builds upon the economic development perspective on climate change of Hitz and Smith (2004), suggests that

> "there are potentially many actions, particularly in developing countries, that can be taken today for reasons that are more directly related to a broad variety of other developmental goals (including reduced vulnerability to existing climate variability)...[I]t may be possible to redesign some no regrets actions with a little more climate change protection at relatively low additional costs" (Callaway, 2004).

In many cities of South Asia, where municipal decision-makers face a range of serious challenges, this principle can be incorporated most easily into the existing planning processes in order to engender incremental reductions in climate risk.

Despite its potential usefulness, the different interpretations of the "no-regrets" approach complicate a definitive judgment of its specific applicability to, and utility for, Kolkata and Dhaka, but it may offer highly efficient, though probably incremental, benefits for climate-adaptation planning in South Asia. Overall, the primary benefit of a "no-regrets" planning approach stems from the fact that it facilitates overcoming resistance to adaptation efforts, both because it is generally less resource-intensive than are dedicated adaptation measures and because it can be easily integrated into ongoing planning activities.

In addition, given its potential usefulness in the context of South Asia, the no-regrets approach also offers an appropriate framework within which to assess the other models of adaptation discussed below.

"Transformational" Adaptation

A new thematic strain, coined as "transformational adaptation",[11] has also begun to emerge in the climate-change literature. This approach to adaptation arises from the premise that, in order to make a palpable difference in situations of grave vulnerability, rapid, systemic, broad-based actions are required to produce significant amelioration of the effects of climate change. It relies upon the concept of "adaptation at scale", according to which lasting and truly effective climate adaptation can only occur if it is implemented across geographic and causal boundaries;

[11] "Transformational" aspects have been recognized and elaborated upon originally in the climate impact literature, though the theory is still relatively new to the adaptation literature (O'Brien, 2012).

piecemeal, localized efforts are thus ultimately fruitless or counterproductive.[12] Given the irreversible effects of climate change and its impacts on crucial sectors such as water and health, being able to address multiple impacts of climate change simultaneously and holistically—as transformational adaptation advocates—may theoretically deliver the most far-reaching results. However, such an approach may appear similar to the traditional arguments for "comprehensiveness" in planning—which have in practice been generally unsuccessful (Hardee and Mutunga, 2010).

Climate adaptation efforts take place along a spectrum of intensity and comprehensiveness. In his recent book, *Adaptation to Climate Change*, Mark Pelling (2010) provides a very useful framework built upon "the three visions of adaptation". These classifications—resilience, transition and transformation—differ in their "levels of engagement with specific social systems". In his explication, *resilience* corresponds to the most limited of the categories of adaptive actions, while *transition*, likewise incremental in nature, refers to a situation in which the engagement of the governance regimes has the intent of assuming "full rights and responsibilities" for action "rather than making changes in the regime." He positions *transformation*, which he describes as the "deepest level of engagement", in socio-political, economic, cultural, and developmental discourses; this vision addresses security and risk related to climate change. For example, increasing *resilience* could mean that families in flood-prone communities take individual action, such as stockpiling supplies to tide them through floods. *Transition*, in the same situation, might include local or state governments further aiding such communities by providing flood shelters, planning evacuation routes, or establishing early-warning systems. *Transformation* in this case, could involve permanent relocation of communities, where adaptation is ground-up, permanent and supported or accepted by all public and private stakeholders.

In distinguishing transformational from incremental adaptations, as in the case of *resilience* and *transition*, the authors go on to outline three primary characteristics of transformational approaches. First, the fundamental underpinning of such actions is that they are "adopted at a much larger scale or intensity". Second, they generally embody innovative approaches and/or "are novel to the particular region or resource system". Third, such adaptations may entail a change of location or "transformation" of place.

[12] Researchers acknowledge that certain adaptations are transformational for some scales and not for others.

An example of "change of location" could include relocating coastal communities to a new place to reduce their vulnerability to sea-level rise as mentioned in the earlier example. Similarly, the introduction of mass rapid transit systems, a measure that engenders dramatic economic, spatial, and behavioral changes while satisfying a central adaptive component, could be considered a "transformation of place". These shifts may also be accompanied by "fundamental changes in institutional arrangements, priorities, and norms". While transformational adaptation is generally viewed as planned and anticipatory collective action, sometimes autonomous and reactive adaptations can have transformational impacts as well.

Based on a similar premise as Pelling, but extending the concept further—by situating it primarily in the context of large-scale vulnerability and risk—Kates, Travis, and Wilbanks, (2012), assert that transformational adaptations are needed where "incremental adaptations are not enough". According to the authors, transformational adaptation becomes necessary when the vulnerabilities and risks within systems become so acute and substantial that they cannot be effectively addressed short of "novel or dramatically enlarged adaptation." The changes in, and eventual extinction of, agriculture in some rural parts of Bangladesh serve as an illustration for such *transformations*. For example, in many coastal, flood-prone parts of the country, saline intrusion and repeated flood related inundations of agricultural fields had initially forced farmers to alter their farming patterns, replacing the formerly ubiquitous rice paddies with other seasonal cash crops or using drought- and saline-resistant seeds to counter the effects of climate change. Such incremental adaptations, however, have proven insufficient in many areas, as eventually. The complete degradation of coastal farms has forced many farmers to permanently relocate and change their means of livelihood.

The concept of "transformational adaptation" represents a valuable addition to the literature of adaptation, especially where large-scale interventions to address the rapid, deleterious impacts of climate change are not merely desirable but actually necessary (as in the case of agriculture of Bangladesh). This approach to adaptation, however, is still in its nascent stages. Making transformational adaptation truly useful requires further research to expand its range of applications and align its principles with concerns of risk assessment and cost-benefit analysis. The fact remains that, since incremental adaptations engender significantly less resistance, transformational adaptations have proven far harder to implement (Kates, Travis, and Wilbanks, 2012). Effecting the dramatic changes required by a transformational approach means simultaneously managing socio-political, economic, cultural, and developmental concerns while securing the active engagement of both public and private entities. The chances of incorporating such transformational approaches into current public policy thus remain fleeting at best.

Discussion

Though neither the mechanisms of implementation for, nor the broader implications of, transformational adaptation are fully understood yet, its underlying principles hold promise, especially in situations in which only a radical overhaul of "business as usual" practices of development can address systemic vulnerabilities. Such a case could result when coastal lands are submerged due to sea-level rise, where the relocation of entire communities becomes necessary because previous adaptive designs of buildings (e.g., construction of houses on stilts) may no longer be a feasible recourse.

Transformational measures potentially offer the greatest long-term positive benefits for climate-change adaptation, especially in regions, like South Asia, where climate-related impacts are increasingly deleterious. The escalating consequences of these climate impacts demands nothing short of fundamental alterations in how these cities manage climate issues; transformational adaptation could indeed play a pivotal role in furthering effective adaptation measures and policies.

However, the main hurdles to implementing "transformational adaptation" in South Asian mega-cities are much in keeping with the general barriers facing other efforts toward climate-change action, including institutional inertia, constrained resources and capacity, ineffective and corrupt governance, and blurred lines of authority and responsibility. As with any anticipatory adaptation planning, the uncertainties of climate-change risks and their consequent impacts always raise questions about the appropriateness of the level of adaptation and its likely benefits. Additionally, given the daunting "perceived costs" of such large-scale adaptations, where a realistic cost-benefit analysis is not possible to justify such actions, the difficulties associated with planning and implementation become significantly more prohibitive. In South Asia, where municipal resource allocations even for basic planning endeavors are woefully insufficient, leave alone those that address adaptations at such large scales, these difficulties are even more pronounced. Apart from the provision of resources, institutional inertia also remains a major obstacle to the adoption of innovative measures that disturb the *status quo* of planning practices and policies that are embedded in a system that is hampered by corruption and obstructionist bureaucracy. Finally, even if sufficient resources were available, such transformational actions could exacerbate the existing, severe social and economic inequalities. Seen from a different perspective, the forced relocation of farming communities from flooded areas, for example, dramatically impairs the social cohesion, economic status, and employment options of the entire community; in short, this uprooting threatens the community's very existence. Since typically the poorest areas face the greatest climate risks, socioeconomic divides are thereby exacerbated through such relocations, raising serious concerns over equity and fairness. Moreover, for transformational adaptation to be truly successful, all actors involved must demonstrate "the deepest level of engagement", something often lacking even in far more modest efforts. Focusing on large-scale transformational efforts rather than on direct poverty alleviation and economic development—issues considered more urgent by many—may diminish both the public support for such measures and the extent of "buy-in" among various stakeholders.

Despite these seemingly insurmountable obstacles, a few "transformational" (though not related to climate change) planned developments have been implemented in South Asian mega-cities. For example, the introduction of the Delhi Metro in the year 2000 has not only created massive changes in the transportation modes and commuting behaviors of the residents, but also engendered strong economic development and employment mobility because of the dramatically increased access network. Though the long-term success for this transformation is difficult to predict at this time, three factors may increase the likelihood of transformational adaptations becoming integrated into planning policy and practice eventually. First, mega-cities in the Global South are not strangers to large-scale changes in various arenas, some of which have "leap-frogged" the traditional developmental and technological trajectories. A compelling instance is telephony, where the accepted path of development long dictated that broad access to landline phones accompanies GDP growth and necessarily precedes mobile communications. In India, for example, however, landlines have never gained traction, peaking at fewer than 32 million fixed lines, while India has about 900 million mobile phone users—a majority in rural areas—and a more extensive cellular network than that of the US (World Bank Databank, 2012). Second, as is often the case in South Asia, a series of large-scale incremental changes can accrue to reach the level of "transformation", a pathway that the authors themselves outline. Third, given the increasing impacts of climatic and anthropogenic change in South Asia, the levels of vulnerability and impacts in these cities may reach a tipping point at which the country may have no recourse save to engage in transformational adaptation, to survive. Such a tipping point could result from a crisis in water supply, where stringent water conservation and management policies, accompanied by substantial increases in water prices, might change the way in which people use and conserve water.

It would seem, however, that such a tipping point remains many years, if not decades, away for the mega-cities of South Asia. Moreover, climate change is essentially a linear rather than a threshold problem, with continuously escalating impacts; the tipping point is thus a question of mobilizing sufficient political consensus to effect substantial change. The principal, realistic tipping points that can mobilize the political will for comprehensive climate adaptation are therefore catastrophic events, which offer the "potential for transformative political space to be opened by disaster" (Pelling and Dill, 2010: 23).[13] In this regard, transformational adaptation appears necessarily reactive in nature, with major alterations occurring in response to, not in advance of, climate-related devastation.

Though the authors seek to emphasize the practical utility of the approach, transformational adaptation, unlike the no-regrets approach, does not seem to offer a viable or practical pathway to overcoming resistance to policy change. Moreover, the track record of comprehensive planning in the Global South is a rather poor one. On the other hand, incremental adaptation processes (e.g., "no-regrets") that can be incorporated into "regular" planning initiatives are much more likely to be implemented and to reach their stated objectives than are comprehensive plans. Thus, at this juncture, transformational adaptation can be best viewed as a theory of how planning *should* be conducted, rather than as a set of practical guidelines for the planning of climate-change adaptation.

[13] Pelling and Dill (2010), provide a thorough discussion of the relationship between disasters and political power dynamics.

Adaptation as Development: *Vulnerability Reductions & Adaptation* Approaches

Scholars and practitioners alike have increasingly come to realize that sustainable development needs to be a central component of planning agendas, insofar as climate adaptation and sustainable development are inherently linked and play a determinant role in responding to risk (Schipper, Cigaran, & Hedger, 2008; McGray et al., 2007). In fact, the emerging development paradigm for climate adaptation corresponds to the view that

> "Development activities could be concerned with sustainable development and reducing vulnerability ...[and] represent an opportunity to revisit some long-standing problems of environment and development" (Schipper, 2007).

In practice, however, development projects in South Asia have not taken advantage of this opportunity. In Dhaka, for example, much of the urban wetlands[14] has now been filled up and replaced by residential housing; development has thus significantly reduced the adaptive capacity of the entire urban region. If wetlands development had played a dominant role in responding to risks for climate change, as advocated by the idea of "adaptation as development", such development would have been planned around the wetlands in an environmentally conscious fashion.

In the current climate-adaptation discourse, the theoretical discussion of the normative approaches to "climate adaptation as development" consists of two primary approaches: the "adaptation approach" and the "vulnerability reductions approach". Each of these frameworks recognizes that climate change is as much a "natural" phenomenon as it is one that is increasingly exacerbated by intervening conditions caused by human agents, thereby creating intricate linkages between climate change and development.

The "adaptation approach" views planning for climate change as a means of both responding to climate-related events (gradual and extreme) and channeling development (Schipper, 2007). The "vulnerability reductions approach" posits, as the name suggests, that increasing the coping

[14] The urban wetlands of Dhaka have been critical to maintaining the environmental balance for the city: they have traditionally both served as retention ponds for floodwater and inhibited excessive runoff and depletion of groundwater tables.

capacities of vulnerable populations, without causing cultural or economic dislocation, can best augment their resilience to environmental and climatic change (Satterthwaite, 2009). The lessening of risk for such populations in turn should create enabling conditions for effective adaptation, since the most urgent threats have already been somewhat contained. Such emphasis on limiting more immediate concerns helps to further the larger agenda of sustainable development in the long-run (Schipper, Cigaran, and Hedger, 2008; Srivastava and Heller, 2003).

Adaptation Approach

The "adaptation" approach assumes that "adequate development will automatically reduce the levels of relative or total risk" and that adaptive capacity is greater when countries are better developed and hence have a "stable and prosperous economy" (Lavell, 2004). The recent case of superstorm Sandy in 2013 in New York illustrates how adequate development correlates with reduced risk levels. New York experienced far fewer casualties and less disruption than did other mega-cities that faced similar storms, such as Dhaka or Mumbai. This is true, largely because New York (like other cities in the developed world) boasts relatively robust and adequate development.

In addition, the authors also contend that the "adaptation approach" can link various aspects of growth to a set of sustainable practices from inception, limiting the need for later interventions and potentially serving as a primary mechanism for climate adaptation.

Vulnerability Reductions Approach

The "vulnerabilities reduction" approach refers to a pathway for adaptation through addressing vulnerabilities; its responses generally fall within the larger category of sustainable development (Fussel and Klein, 2006; Chapin, 2006). On the city level, for example, addressing a particular vulnerability (e.g., using sound water management policies and adequate infrastructure development to combat the gradual deterioration of quality and supply) not only resolves the immediate issues, but also ultimately strengthens the overall adaptive capacity of the city. Higher adaptive capacity in turn reduces the possibility of long-term climatic risks. Additionally, the responses within this approach can also include other types of measures. For example, in terms of engineering and technology, initiatives such as planting drought-resistant seeds for agriculture are included, while in the socio-economic aspects, responses that include alleviating poverty by enhancing livelihoods are also advanced (Ford, 2007) Planting drought-resistant seeds not only increases the adaptive capacity of farmers, but also decreases their overall vulnerability to losing their crops and livelihoods during climate-related drought periods. Similarly, from a socio-economic perspective, providing vocational training and support to poor people—in order to enable more consistent and higher sources of income—in turn increases their coping capacities and renders them less vulnerable to climate risks.

Applicability of these frameworks

Though both the "adaptation" and "vulnerability reductions" approaches are primarily rooted in the concept of "adaptation as development", each brings different advantages. In the case of the "adaptation" approach, the first benefit lies in the integration of climate adaptation into development; adaptive measures thus become relatively simpler to implement from a policy and planning perspective. This is particularly useful in situations in which it is hard to take concrete measures in the face of uncertainty, as in predicting the specific effects of climate change (Adger and Vincent, 2005; IPCC, 2001; Lynch and Brunner, n.d.)

Second, development efforts that offer broader economic benefits—as the adaptation approach claims to do—can engender stronger political will and institutional support than can isolated adaptation efforts that bring only limited ancillary benefits. This is clear in the case of the East Kolkata Wetland Systems (EKWS) in Kolkata. Conservation and proper management of the EKWS have afforded the city many benefits, bringing increased institutional and private stakeholder support. Apart from the environmental benefits in acting as natural drainage systems, water-retention areas, and grey-water purifiers, the EKWS ponds also provide significant economic advantages. The ponds themselves serve as fish farms, while the arable part of the wetlands provides a continued supply of local agricultural produce for the city and a means of livelihood for many residents.

Conversely, unlike integrated methods which also have the capacity to address the larger socio-economic vulnerabilities of a system (Ford, 2007; Ford et al., 2007; Tschakert, n.d.) (as in the adaptation approach), "one-off" measures of adaptation may in fact be rendered ineffective in the longer term (Ford, 2007). The construction of sea walls along coastlines is a typical example. As a one-off measure, such an initiative may have the capacity to ward off coastal storms in the near term. However, with the gradual rise in sea levels and increased frequency and intensity of coastal storms, the sea walls may be breached in the long-term. Piecemeal measures such as sea walls in effect can counter the immediate problem while generally protecting only adjacent areas. Moreover, such projects generally incur large initial expenditures and huge sunk costs, while offering no lasting socioeconomic betterment.

The advantages of the "vulnerability reductions" reside more in issues of equity than in issues of planning implementation and cost-benefit analysis, as in the case of the "adaptation" approach. Schipper 2007, for instance, holds that the "vulnerability reductions approach" is more constructive and equitable because it can increase the coping capacities of the most vulnerable sections of societies to both climatic and non-climatic risks. Moreover, reducing vulnerability may ultimately contribute to overall development; the provision of piped water supply in slum areas of a city, for example, illustrates Schipper's argument for this theory. Furnishing clean water reduces the vulnerability for the slum dwellers; ensuring a steady provision of water of the same quality as that supplied to the rest of the city promotes equity. Moreover, access to potable water diminishes the incidence and direct costs of disease and illness (including cholera, malaria, and dysentery) and increases general productivity. In addition this measure also enhances the overall standard of living in these slums and may increase land values of immediate and adjacent areas, leading to enhanced development.

Other related concepts

Within the larger construct of "adaptation as development", McGray, Hammill, & Bradley (2007) elucidate yet another relationship between adaptation and development and propose a development-adaptation continuum rather than dual, competing objectives. The authors provide two useful perspectives on the *processes* of development, based on their findings from an investigation of 135 related "adaptation" activities. These two categories—serendipitous (unintentional) and linked (intentional) adaptation—clarify many of the distinctions among these two approaches.

The first, known as "serendipitous adaptation," is defined as "activities undertaken to achieve development objectives [that] have outcomes that incidentally may also support adaptation" (McGray, et al., 2007: 13).

Additionally, this type of adaptation explores development and adaptation that occur under conditions in which "sustainable development can enhance adaptive capacity by strengthening institutions, promoting sound management of natural resources, improving health and education systems...and fostering economic growth" (Islam, Hove, and Parry, 2011). The process of serendipitous adaptation can be observed, for instance, in the provision and maintenance of recreational green areas within densely populated cities. Such a development project not only serves as a recreational outlet for city dwellers, but also brings unintentional or serendipitous adaptation benefits as well. These gains can include reducing heat-island effects, tempering the city's microclimate, and attracting precipitation. Central Park in New York serves as a relevant example: a park primarily intended for beautification now provides serendipitous climatic advantages.

The second process framework, "linked adaptation," also known as "climate-proofing of developmental efforts," is defined as planning activities that are "added to an ongoing initiative to ensure its success under a changing climate. In these cases, adaptation is seen as a means to a development end" (McGray et al., 2007: 13). In such "linked" adaptation measures, the planning process also intentionally addresses impacts of climate change even though the primary goal may be centered on development rather than on climate adaptation. An example for this linked or intentional adaptation would be a road upgrade project that primarily addresses a developmental aim, but also provides incorporates additional stormwater-drainage and redesigned culverts to adapt to climate risks related to flooding caused by intense precipitation.

Discussion

In the context of South Asian mega-cities, both of these development-based approaches offer one shared critical insight: for rapidly urbanizing cities such as Kolkata and Dhaka, adaptation approaches that address concomitant economic, infrastructural, and social development efforts are of central concern. In fact, this nexus of interests underscores most planning activities. As espoused in the "adaptation" approach, integrating adaptation with development makes very good sense and remains simpler to implement from a planning and policy perspective than are stand-alone adaptation activities. Drawing from a previous example, the construction of sea walls, which serve as one-off measures in combating floods, is difficult to plan for and implement because of resource constraints and in some cases the lack of relevant expertise. Conversely, augmentation of stormwater-drainage capacities to absorb added runoffs resulting from overdevelopment (and intensified by increased urban flooding) can ameliorate the same climate risk while enjoying synergies with, and capitalizing on, the existing developmental agenda of the city.

However, given the political struggles, resource constraints and weak institutional capacities of these regions, integration to a level where "adaptation becomes the new development approach" remains a difficult challenge. As my field research shows, adaptation is really only occurring incrementally, whereas overall development is proceeding at a far larger, transformational scale; a broad shift to more intentional efforts to reduce or manage climate-change risks would seem very unlikely in practice. Moreover, these deeply embedded difficulties facing South Asian mega-cities render impractical any perspectives (such as the adaptation approach) in which adaptation serves as a primary focus for development.

The vulnerability reductions approach also provides similar lessons as the adaptation approach does; reducing vulnerability is certainly a viable path to enhancing adaptation. Such enhancement is occurring in numerous ways in the developing world, through provision and expansion of basic infrastructure (as with the supply of safe drinking water and sanitation) and through poverty alleviation measures (as with livelihood enhancement, educational programs, and slum upgrades). Despite these efforts, the fact remains that the needs of a large proportion of the existing city population remain unaddressed, and the rate of population growth far exceeds the rate of development, leaving a large segment of the population still vulnerable to the myriad dangers arising from global warming.

Thus given these inherent challenges in trying to change all development to be adaptive or then trying to reduce the vulnerabilities of such a rapidly growing population as a means of adaptation, these two approaches seem unlikely pathways to adaptation in the current circumstances of the Global South.

Apart from these two primary theories, a brief contextual analysis of the "serendipitous" and "linked" adaptation approaches is also necessary. Serendipitous adaptation, by its very nature, is not a viable stand-alone option by which to engender effectual climate adaptation, as the benefits generated are at best secondary and ultimately "left to chance". Linked adaptation, on the other hand, would require a fundamental reworking of the current planning schema to purposefully "link" development with adaptation activities. First, this approach would require the allocation of additional resources and capacity—as the scope of these plans would have to be considerably enlarged. Second, institutional inertia, lack of collaborative expertise, and lack of political will in addressing adaptive issues (which are seldom prioritized over the more visible larger developmental planning endeavors) would also remain substantial barriers. In light of these inherent drawbacks of both linked and serendipitous adaptation in the Global South, the no-regrets approach still remains the most easily adoptable framework, one which offers the ability to overcome the key barriers experienced in South Asian mega-cities: limited resources, rigidly bureaucratic institutions, and implementation efforts hampered by corruption and a lack of coordination.

Integrating Adaptation with *Disaster Management* and *Mitigation*

Relationship with Disaster Management

Climate-adaptation actions often require collaboration across several agencies and among numerous stakeholders. Depending on the type of climatic risks that need to be addressed (e.g., sea-level rise or heat-island effects), various concerns, including ecological and natural resource management and sewage and wastewater systems, remain inextricably linked to adaptation efforts (Fussel, 2007a). A number of scholars have found similar synergistic connections between adaptation and Disaster Risk Reduction (DRR) and Management (DRM) as well. (Adger, et al., 2003; Hewitt, 1983, 1997; Sen, 1981; Ribot et al., 1996). Given that many cities of the Global South lack specific adaptation plans at the local level and rely largely on DRM efforts to combat climate-related impacts, generally it's aftereffects, the understanding of potential overlaps among areas of disaster management may provide substantive guidance in shaping effective climate-response strategies. Such a view proves especially valuable in resource-constrained environments where efforts to achieve public-policy goals need to be combined; hence, DRM, which may include emergency-preparedness or emergency-response measures, represents a useful lens in viewing adaptation.

Nevertheless, the dearth of actual disaster-response measures or disaster-preparedness plans for South Asian cities would suggest that integration of these areas has not been explored by local planning agencies in depth, if at all. For example, Kolkata has yet to adopt a formal local climate-adaptation plan despite the many climate-related risks and extreme events that the city faces. It does possess a rudimentary Disaster Management Plan (DMP), a framework that leans more towards centralized, reactive relief efforts than towards comprehensive disaster mitigation. The DMP had moreover never actually been applied before Cyclone Aila in 2009, and given the intense devastation and inadequate response in its aftermath, would appear to be ineffective (Menon, 2009). Integrating DMP into adaptation planning has not even been considered, even though the benefits such collaborative planning efforts would seem obvious.

In Dhaka, the Government of Bangladesh's Disaster Management Bureau oversees disaster management efforts, principally through the technical division of the Disaster Management and Relief Division (DMRD), which is also run by the national government. Though the DMRD is headquartered in the city itself, the Bureau's actions are not well-coordinated with the adaptation or planning efforts of city agencies. During emergencies, however, the response functions are evaluated in "close collaboration with District and Upazila (county)-level authorities and the concerned line ministries under the overall authority of high–level Inter-ministerial Disaster Management Coordination Committee (IMDMCC)" (see DMB.gov.bd). Cooperation among authorities is thus somewhat greater—though nevertheless inadequate—in disasters and at larger (district and county) scales. Coordination of adaptation and DRM efforts for normal development activities remains scant and infrequent, however.

In addition to this district-level collaboration, in Bangladesh, the Standing Orders on Disasters (SOD) formulated by the DMRD and allied national agencies provide for a Disaster Management Committee at the city level. The Dhaka City Corporation's Disaster Management Committee (DMC), led by the Mayor, consists of fifteen other city-level officials representing the police, the health directorate, and the agriculture, water, and electricity boards, among other agencies. There is also an NGO representative who is nominated by the DCC. Despite this formal institutional arrangement, which provides a natural opportunity for integration of efforts, the responsibilities of the DMC are extremely limited.

During "normal" times, the Committee disseminates cyclone and flood forecasts to the concerned local organizations, identifies potential shelters and allocates responsibility to different city entities to oversee them, and organizes periodic mobilization drills. During disasters, the scope of responsibility centers mostly on administration and organization. The DMC manages the emergency operation center and coordinates evacuation, rescue, and relief efforts. In addition the Committee disburses resources received from the National Government to participating local agencies, keeping accurate accounts and distributing rehabilitation funds to other agencies in charge of remittances to the public (3CD City Profiles Series, 2006).

Although the Committee ostensibly serves as the formal institutional structure that could integrate various city-level climate adaptation and disaster management efforts, in practice little such integration actually takes place. The DMC could build on the national efforts to extend adaptation efforts locally, drawing upon a broader resource base and engendering more efficient operations. These opportunities could present themselves in a number of ways. At the very least, sharing information about hazard diagnosis, climate forecasting models, and vulnerability assessment—data already compiled by various national agencies—could have obviated the need to hire experts at the local level for similar efforts. A stronger collaboration between the DMC with the existing DRM efforts, especially in the planning phase, could also provide a forum for strategic and policy advances to further Dhaka's adaptation goals. Such adaptation objectives could include the preservation of urban wetlands, which would augment more ambitious national disaster-management efforts to control floods while helping to chart and enforce local land-use plans in an adaptive fashion. Another such opportunity presents itself in the water-management sector, where national-level data on water contamination and availability could be disaggregated easily to formulate a basis for local supply planning. In addition to such long-term planning integrations, the city agencies, in concert other organizations and in keeping with the DRM efforts, could have built on the political momentum from recent major disasters, such as Cyclone Aila, to strengthen and fund city-level adaptations while furthering the national climate agenda. Unfortunately, none of these options has yet been actively pursued, though several interviewees in related agencies indicated their eagerness to collaborate on such initiatives (Interviews 30, 31, 32, 33, 35, 36, 37, 38 and 40).

The lack of any meaningful integration between local adaptation and national disaster management can be attributed to a number of factors. Historically, the national government has taken the lead in disaster-management efforts and has established dedicated agencies to oversee these measures. Moreover, local officials have little prior expertise in such matters; the rigid hierarchical structure of the relevant governance structures in Bangladesh, in which the national agencies hold the political and financial power, has only allowed for the delegation of isolated responsibilities rather than more meaningful exchanges. Recent research suggests in fact, that the nation's overly centralized administrative structure represents a major impediment to adaptation planning and implementation (Islam, 1996). Collaboration between national and local agencies is complicated by the complex web of forty local organizations, characterized by overlapping jurisdictions and areas of responsibility (cite). Though it is possible to empower the DMC to oversee these functions on the city level, in reality the existing political struggles among different agencies in Dhaka and nationally might prove counterproductive if the scope of the Committee were expanded in this manner without a complete overhaul (LGRDC and ADB 2005).

In effect, the major responsibility for city planning rests with RAJUK and the DCC. Both of these bodies are underfunded and are already burdened with an extensive portfolio of responsibilities. Given the circumstances, they have proven unwilling to take on the added obligation of disaster management or collaborate with national agencies to find ways in which they can extend their own adaptation efforts. Since funding for climate adaptation and disaster management is controlled primarily by the national government, such collaboration offers no additional incentives at the onset. Moreover, disaster-related efforts are already a highly politicized subject in Bangladesh; linking city-level plans to disaster management may result in greater accountability and political and public scrutiny for RAJUK and the DCC, something the officials in each agency wish to avoid (Interviews 36, 37, 38, 39 and 41).

Although in practice the linkages between disasters and adaptation have not been successfully integrated into the planning schema of most South Asian mega-cities, scholars have explored the commonalities and synergies between climate-change adaptation and disaster studies (Alam and Rabbani, 2007; Birkmann et al., 2009; Kousky et al., 2009). These researchers have examined the significant reforms that ensue from natural disasters, distinguishing such systemic shifts from immediate impacts to long-term responses, and have realized that major disasters can alter dominant behaviors and attitudes toward long-term, climate-related changes (Sherbinin, Schiller, and Pulsipher, 2007; Huq, Kovats, Reid, and Satterthwaite, 2007; Schipper, Cigaran, and Hedger, 2008; Betsill and Bulkeley, 2007; Satterthwaite et al., 2007; Pelling and Dill, 2010). In fact, residents of coastal cities actually perceive the risks resulting from climate change, such as flooding and catastrophic weather events, more acutely than do most residents of inland cities, suggesting greater public pressure for adaptive measures. Davidson, Williamson, and Parkins (2003) cite risk perception as a crucial motivator in risk assessment and argue that entities are much more likely to attempt to respond to risk under such exigent circumstances; heightened risk perception prompts "actions that lead to adaptive strategies" (Parkins, 2008).

This alteration of dominant attitudes prompted by a heightened perception to risk because of the repeated, escalating impacts of natural disasters is clearly evident in the policy changes that have occurred in Bangladesh. The history of repeated flooding and ensuing destruction has been a major factor in focusing on climate adaptation programs in the past decade to a great extent (cite). Moreover, the national policies, as seen, for example in the national *Bangladesh Climate Change Strategy and Action Plan* (2008) prepared by the Ministry of Environment and Forests, clearly suggest that the country is aware of the severity of the climate risks it faces and of the need for extensive adaptation efforts. However, national policymakers are yet to make the leap (at least in practice) that climate change adaptation requires knowledge, institutional capacity, and effective governance particularly at the local levels, for it to be truly effective. This deficiency reveals itself in the lack of concrete action by the national government to carry out thoughtful policies and directives that are truly collaborative with, and supportive for, local agencies.

Given that disaster-related impacts bring underlying issues to the fore, the study of changes that are catalyzed by disasters but that influence decision-making trajectories beyond the immediate event may also provide valuable insights that reduce the complexity and uncertainty of climate-change adaptation in the long-term (Parkins, 2008; see also Adger, Brooks, Bentham, Agnew, and Eriksen, 2004; Brooks, 2003). Moreover, such catastrophic events may marshal broad-based political support for workable systemic changes. Many scholars in this field consider the role and actions of institutions essential to developing adaptive capacity (Adger, 2000; Adger & Kelly, 1999; Handmer, Dovers, and Downing, 1999) and argue that decision-making in response to internal and external forces is largely a function of institutional adaptation (Adger, 2000). Leveraging such public support in the aftermath of crises thus appears to be a crucial step in overcoming bureaucratic stagnation and intransigence.

Building on the linkages between climate-change impacts and climate disasters, the research on response options for climate-related catastrophes also offers useful recommendations for decision-making under uncertainty. This is especially true in cases of cascading consequences, where resource limitations and the need for immediate responses often inhibit more ambitious and longitudinal efforts to address underlying causes and systemic weaknesses. Kousky et al. (2009) note that, while it is impossible to identify all cascading consequences, focusing on those that we can reasonably predict offers significant room for ameliorative action. In the same vein, Posner (2005) suggests an approach in which the desired level of effort on risk reduction can be estimated against the long-term overall costs and benefits of such efforts.

An illuminating example of this can be seen in the land-development practices in Dhaka. In the past year, several buildings located in earthquake-sensitive zones—largely former wetlands—have collapsed. Had the city agencies evaluated the cost of producing a detailed area plan (DAP) that regulated development (the cost of risk reduction) against the subsequent massive outlays incurred with the collapses (overall cost and benefits), these agencies might have altered their initial decision to leave the buildings in place. Moreover, when the cost of adaptation options varies widely, gradual measures, such as stricter land-use regulations, would be less resource-intensive, thereby enabling a reduction in the overall cost through "circuit-breaker"[15] responses, which limit the impacts of climate-change catastrophes through prior planning (Kousky et al., 2009). In South Asia, where resources are often channeled to deal with exigent climate disasters such as floods and tsunamis, and long-term climate-planning decisions often remain contingent upon available resources, less costly adaptation options that can moderate the cost through such circuit-breaker responses[16] to climate catastrophes are worth investigating, as are potential synergies between these two sectors.

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[15] An example of a "circuit-breaker" response in the event of a climate catastrophe, such as a severe flood, is to identify evacuation routes and flood shelters beforehand and ascertain the availability of provisions to prevent cascading consequences, such as additional deaths among the most vulnerable populations resulting from contaminated water supplies and inadequate refuge.

[16] Another example of a circuit-breaker response that can both reduce the severity of the impacts of a disaster and serve as a relatively low-cost adaptation measure for the city is management and preservation of urban wetlands. During floods, the wetlands serve as natural drainage channels and retention ponds, while the same catchment areas have the ability to replenish the water table and decrease the urban heat island effects of

Relationship with Mitigation[17]

Many climate scholars also argue that, although the interrelationships between mitigation and adaptation have been largely neglected in planning, an "integrated approach" in this sphere would nonetheless provide a robust platform for sustainable development while augmenting readiness for climate change impacts (Davoudi, Crawford, and Mehmood, eds., 2009; Tanner, Mitchell, Polack, and Guenther, 2007), Swart and Raes, 2007). However, since mitigation focuses primarily on the reduction of greenhouse gases and emissions, the effects of such actions on climatic change[18] would be felt only in 50-70 years—too late to avert numerous catastrophes—even if mitigation efforts were pursued aggressively. The delayed benefits of mitigation make adaptation necessary for the short- and medium-term, regardless of the scope of any mitigation efforts undertaken.

The case in India illustrates this temporal relationship between mitigation and adaptation while speaking to the necessity for current adaptation. In the absence of effective enforcement of mitigation policies, India, the world's seventh-largest country in area and second-largest in population, remains extremely vulnerable to climate change, as do many other nations in the region, most notably, China, Bangladesh, Sri Lanka, and Pakistan. Moreover, India's economy is tied largely to its natural resources, and much of its rapidly growing population resides along its 7500km-long, densely populated coastline, underscoring the nation's dependence on climate stabilization[19] and availability of natural resources.

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densely populated cities.

[17] Adaptation was linked to mitigation on the basis of societal costs for the first time in 1997 at the Kyoto Conference of the Parties of the UN Framework Convention on Climate Change (FCCC).

[18] The IPCC notes that GHG emissions need to be immediately cut as much as 60-80% in order to stabilize global temperatures, an obviously unrealistic goal given current dependence on fossil fuels globally. Peter Odell of Erasmus University, for example, estimates that, even by the year 2100, renewable energy sources will account for just over a third of world energy consumption, with oil consumption only peaking in 2050 (Johnson, 2009).

[19] Various studies show that the surface air-temperature in India is rising at a rate of almost 0.4°C every century, peaking during the winters and post-monsoon seasons.

Emissions increase due to rapid development has contributed greatly to the warming of the sub-continent[20], which in turn has had numerous deleterious effects; changing climatic conditions, water crises, and food security are some of the cascading threats. Of these, the difficulties in the water sector may be most pressing. The monsoons, which greatly augment the region's biodiversity, remain an integral part of the support system for this region's agricultural and water needs. The region also depends heavily on the water sources from the glacial melting[21] of the Hindu Kush and Himalayan regions.[22] Increased temperatures naturally result in increased glacier melt; in India, the melting season coincides with the summer monsoons. The resulting upsurge in water flow within the sub-continent also generates increased rainfall, in turn contributing to larger climatic threats, such as "flash" and regular floods. In combination with this rise in water flow, thermal expansion of the Indian Ocean[23] (likewise a consequence of rising temperatures) brings serious environmental consequences. This expansion is already causing flooding in low elevations (including the crucial coastal mangroves and marshlands) and escalating levels of salt intrusion through sea-level rise in fresh-water rivers, streams, aquifers, and wetlands. Such environmental repercussions, coupled with the loss of substantial areas of mangrove forest, will not only disturb the region's biological equilibrium, but also debilitate the natural protection against hurricanes and typhoons that such ecological features offer, particularly along coastlines. Additionally, the

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[20] Between the 1950's and 80's, the temperature of the Antarctic Southern Ocean rose at twice the rate (0.17°C, or 0.31°F) of global ocean temperatures.

[21] Higher surface temperatures are leading to accelerated glacier melt, even in the South Asian Himalayas; the ensuing intense flash floods have devastated the lower valley regions. For example, in 1994, the overflow of a glacier lake caused huge floods in many villages in the Lunana region of Bhutan, while in 1997 similar effects were seen in the Dudh Koshi Lake in Nepal. According to experts, this trend is expected to accelerate in the next five years and spread beyond the immediate Himalayan region to encompass larger parts of South Asia.

[22] Because of rising temperature, the Himalayan glaciers are expected to disappear by 2035, with disastrous consequences: some of Asia's biggest rivers, including the Ganges, Indus, Brahmaputra, Yangtze, Mekong, Salween and Yellow Rivers, flow from these glaciers. 2.4 billion people across India, China, Pakistan, Bangladesh, Nepal and Myanmar depend on these rivers for drinking water, farming and other related activities.

[23] The Indian Ocean is expected to rise by 25-40 cm due to thermal expansion, while records indicate that sea levels on Indian coastlines have been rising at the rate of 1 cm/decade.

rising temperatures have also resulted in a "raised" snowline, wherein the future water-producing capacity of these glacial melts has reduced markedly. The consequences of this perturbation of water cycles are alternating periods of seasonal flooding and water scarcity. These shifts lead to diminished agricultural, fishing, and aquacultural production, shortages of fresh water[24], influxes of climate refugees in urban areas, and loss of land or livelihood among large populations who rely on riverine resources, as well as numerous ancillary ecological, social, economic, and public health impacts[25] (Ford, 2007). These deleterious results of climate change are as much issues of unaddressed or delayed mitigation as they are challenges for adaptation planning. Moreover, the developments outlined above suggest that lack of mitigation has certainly been a major contributor to the warming of the sub-continent, which in turn has exacerbated glacial melts.

Even if mitigation efforts were fully enforced now in the wake of such impacts, since the positive effects of mitigation actions will not be felt for several decades, increased mitigation efforts will not significantly curtail the effects of climate change that are now occurring. Hence, adapting to these effects of climate change, such as excessive flooding and loss of agricultural land, is necessary, at least in the medium term. Moreover, since mitigation efforts in India and elsewhere will only work in concert with global cooperation on the issue—far from a certainty, especially in the near term—the need for adaptation is unlikely to go away (Susskind, 2010).

Though adaptation is still essential, the extent of mitigation efforts does have many direct and indirect implications for adaptation efforts. The interdependent impacts of mitigation- and adaptation-oriented policy measures make both their synergies, and their counteracting aspects critical. The specific nature of mitigation efforts in place now will undoubtedly affect the levels of adaptation needed in the future. Much of the literature likewise emphasizes that the relationships between mitigation and adaptation have to be evaluated comprehensively, if the

[24] Studies show that, by 2025, about two-thirds of the world's population will experience water shortages (UN-Water, FAO, 2007).

[25] Climate Change in Southeast Asia estimates that by the year 2100 the rate of combined annual GDP loss in this region could be as high as 7%, about twice the estimated global average loss in GDP.

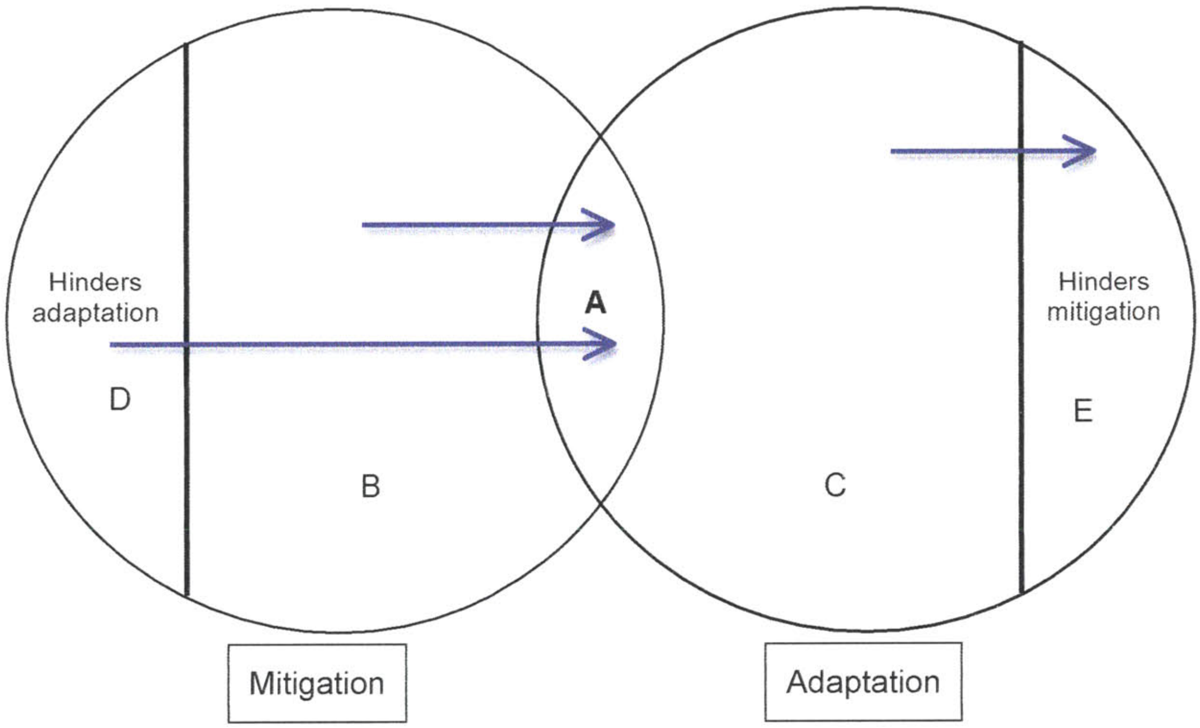
two approaches are to provide a realistic framework for combating climate change. Howard (2009) makes a strong argument for this and laments the "lack of systematic attention in the planning literature to tensions between and potential complementarities of mitigation and adaptation." Harmin and Gurran (2009) similarly acknowledge that an integrated view of mitigation and adaptation cannot regard these approaches as purely complementary and that, in some instances, mitigation can be at odds with adaptation;[26] in such cases, focusing "principally or exclusively" on either adaptation or mitigation can bring greater benefits.

In other instances, however, integration of the two approaches is possible, or even natural. What Howard (2009) terms the "sweet spot"—the area of overlap in which policy or planning measures simultaneously serve the purposes of both mitigation and adaptation—thus might represent an ideal target for climate action. Howard "urges planners to operate as much as possible in the sweet spot and avoid adaptation that undermines mitigation." For example, the planting of trees in urban areas falls within the sweet spot, as it captures carbon (thereby providing mitigation) and also cools adjacent areas during heat waves while reducing urban heat island effects overall (aiding adaptation). The preservation of urban wetlands represents an even more compelling example of the synergies. While restoring the urban wetlands will prevent flooding and purify stormwater (furthering adaptation needs), doing so will also sequester enormous amounts of CO2 (furthering mitigation aims).[27]

[26] Two examples in which mitigation and adaptation are at odds with each other are as follows. 1) The use of air conditioners in hot climates is a form of adaptation to high temperatures, but doing so contributes to greenhouse gas emissions, thereby weakening mitigation efforts (Davoudi, Crawford, Mehmood, 2009-chapter 3:46). Moreover, high-density development is often encouraged to reduce GHG emissions, as more compact infrastructure ultimately leads to reduced energy consumption. However, high-density compact development in hot, humid regions has negative adaptive benefits because such development patterns exacerbate urban heat-island effects (Pizzaro chapter 3 p21).

[27] Crooks, Herr, Tamelander, Laffoley, and Vandever estimate the carbon dioxide store in the Ganges-Brahmaputra delta at 970-3020 metric tons, among the largest such deposits in the world, and identify the delta as one with "adequate sediment supply to build up subsided areas to marsh plain elevation" (2011: 42, 36).

FIGURE 3.1: Simple Conceptualization of the "sweet spot" and its relationship to mitigation and adaptation
Source: Howard, 2009



LEGEND

A = "Sweet Spot": mitigation and adaptation support/reinforce each other

B and **C** = Mitigation and adaptation measures, respectively, that neither harm nor support the other

D and **E** = Mitigation and adaptation measures, respectively, that undermine each other

Though the conceptualization of "sweet spot" measures does hold some relevance (as in the example of urban tree-planting), such activities are few and far between in practice. As illustrated in the diagram above, most adaptation measures have little or no impact on mitigation, and vice-versa; some actions of one type actually work counter to the other.

In clarifying the aspects of the mitigation/adaptation interface, Howard (2009) offers three principles for planning for climate change, which upon deeper analysis do pose some operational difficulties. The first, according to Howard is that, in instances in which mitigation and adaptation planning face unavoidable conflict—where recourse to adaptation measures may compromise primary mitigation measures—mitigation should be prioritized. However, in practice, many circumstances demand prioritization of adaptation, even at the expense of mitigation, especially when people's lives and livelihoods are at stake. Dhaka provides a compelling example of such a situation. Urban Dhaka has been plagued consistently by major floods, which have cost many lives and wreaked substantial physical and socioeconomic damage over the years. In this case, the city's limited resources needed to be channeled towards adaptation efforts—building embankments to protect the city—rather than on long-term mitigation measures. According to Howard's first principle, those same funds should have been directed towards mitigation efforts, but given the critical immediacy of the situation, adaptation was undoubtedly more of a priority. This same argument that adaptation needs to be prioritized when threats are of a critical and immediate nature also counters another part of this principle, where he suggests that local adaptation should not undermine global mitigation at any cost, and that "climate costs" should not be externalized. The real problem here arises because such adaptations that externalize costs might constitute merely "superficial action", lessening the impetus for meaningful, systemic mitigation, not because short-term adaptation is inherently counterproductive.

The second principle posited by the author and supported by others, such as McEvoy et al. (2006), is that mitigation should be viewed as a form of adaptation. This view emphasizes that though some mitigation measures do not facilitate adaptation immediately, in the end, practitioners should understand that, "the most desirable form of adaptation is adaptation that is made unnecessary". Moreover, effective efforts at mitigation have the inherent capacity ultimately to reduce the level of adaptation necessary. Though successful mitigation efforts can indeed reduce the need for adaptation in certain circumstances, given the rapid rate at which climate change is taking place, it is also equally important to view these actions within the near-term context. The dramatic rise in greenhouse gas emissions and CO_2 levels since the Industrial Revolution has already engendered significant climatic changes; even immediate, drastic global reductions in GHG levels—extremely unlikely under current political and economic circumstances—would only be felt after several decades. We are already experiencing the effects, from rising sea levels and destructive storm activity to frequent, intense heat waves and droughts. These threats cannot be addressed through mitigation alone, however effective. Consequently, because we have already waited too long to act, adaptation must be stressed as much as mitigation is.

Howard's third principle concerns the responsibilities for the actual practice of adaptation rather than the integration of adaptation and mitigation. He argues for a focus on "local adaptation to require a long-term, global perspective". This principle highlights the political complexities that weaken efforts for addressing climate change globally, as highlighted in the Rio Summit and Kyoto protocols, where the burden of employing mitigation measures is disproportionately distributed. Though poorer nations do have a stronger claim to adapt at the cost of mitigation[28] on the basis of both fairness and their relative level of vulnerability, ultimately such a position, as Howard explains not only undermines global climate-change actions but also hurts the communities themselves in the long-term. However, in practice, the adaptive interests of local development corporations are near-sighted and hence generally engender only short-term benefits at the expense of more encompassing systemic reform. Additionally, local communities lack the necessary leverage to make decisions that further mitigation at sufficient scale necessary to benefit them; sometimes short-term adaptations, even those that do not have a "long-term global perspective" maybe the only options.

In contrast to Howard's position, McEvoy et al. (2006), outline three practical concerns that stem from integrating adaptation and mitigation. First, the actors who initiate mitigation and adaptation are not the same. They often work in different capacities with widely varying institutional agendas, a situation which could result in awkward or ineffective

[28] Pizarro in his chapter (Urban Form and Climate Change: Towards appropriate development patterns to mitigate and adapt to climate change) in *Planning for Climate Change* (2009) holds the position that "If any community has a greater need to adapt by sprawling, it is not Jackson or Brisbane but Kampala and Djakarta."

collaboration, while increasing "institutional complexity", thereby "limit[ing] the efficacy of these measures". Second, from a planning standpoint, identifying an optimal number of synergies "deemed necessary" to make a difference of scale seems improbable. Third, even if these integrations are identified, it will prove difficult to analyze the cost of such measures against their overall benefits to addressing climate change in synergistic approaches, versus utilizing adaptation and mitigation as stand-alone approaches. Yet another concern noted by McEvoy et al. (2006: 187) is that in integrating these two options, there may be "an obvious mismatch in terms of scale, both spatially and temporally."

Hence, in contrast to those who tout the benefits of the "sweet spot" theory, these authors contend that the numerous practical drawbacks of such a focus—even where the two approaches enjoy synergies—outweigh the apparent advantages. This theoretical emphasis on the "sweet spot", when applied to pragmatic, complex planning challenges, may result in projects that "fall between two stools," failing to provide effective return on investment for either mitigation or adaptation goals. Alternately, Klein, Schipper and Dessai (2005), argue for an emphasis on the ancillary benefits of both mitigation and adaptation measures, while cautioning that these accompanying positive externalities often differ considerably. Climate-change mitigation, for instance, often produces significant betterment of air and water quality (Cifuentes et *al.*, 2001), while adaptation frequently serves to reduce a population's susceptibility to major weather events and to stabilize agricultural production.

Discussion

There is considerable discussion in the literature of potential integrations between adaptation and disaster risk management (DRM) (see for example Fussel and Klein, 2003; ISDR, 2006; DFID, 2005), as well between adaptation and mitigation (Howard, 2009; Bruce, 1999, Downing, et al., 1997; Fankhauser, 1998; Callaway et al.,1998; Kane and Shogren, 2000). However, though theoretically valuable, these linkages have some serious practical limitations as discussed earlier, particularly in relation to the integration of mitigation with adaptation.

The line of research on the integration of DRM and adaptation efforts, however, if better utilized, could prove especially useful for a number of reasons, especially in cities of South Asia, where storms are frequent and intense. Climate change will lead to significant increases in temperature and precipitation and catastrophic weather events, including more frequent periods of intense rainfall, resulting in floods and coastal erosion, and more numerous cyclones; addressing these disasters through the lens of long-term adaptation would thus help to correct systemic deficiencies without redundancy in planning efforts. Moreover, the imprecise distinction between climate-change risk and natural-disaster risk will therefore further erode, enabling mutually reinforcing adaptation and DRM approaches. Also in South Asia, where resources are often channeled to deal with exigent climate disasters, such as floods and tsunamis, and long-term climate planning decisions are often financially unfeasible, less resource-intensive adaptation options—those that offer the potential to moderate the cost of such "circuit-breaker" responses to climate catastrophes—are worth investigating.

However, given the aforementioned obstacles, especially the institutional complexities involved, the interagency collaborations required to integrate disaster management and climate-change adaptation do not seem realistic, at least currently. Moreover, the institutional, technical and capacity deficits are strong barriers to formulating and implementing plans that simultaneously address climate change and disaster risk. Another important consideration is that of lack of resources; such integrated plans would require not only high initial investment, but also long-term capital flow to maintain the plan's viability in the rapidly changing context of climate change.

Attempts to combine mitigation and adaptation measures encounter some of the same issues as those impairing efforts to integrate DRM and adaptation: bureaucratic stagnation, resource constraints, and capacity deficits constitute the reality of South Asia. Moreover, arriving at the "sweet spot" in planning for climate change is hindered by "long time horizons; non-linear and irreversible effects; the global nature of the problem; social, economic, and geographic differences amongst affected parties; and the fact that institutions needed to address this issue have only partially been formed" (Arrow et al., 1996). Moreover, the problem of finding the most appropriate integrated planning option is complicated by unstable ecological and societal situations, especially in the extremely dynamic environment of the rapidly developing mega-cities of South Asia, where new information and changing circumstances necessitate constant modifications or revisions of planning approaches (Lempert and Schlesinger 2000; Tóth et al., 2001).

Another problem in combining mitigation with adaptation is that addressing both together might take away the much needed attention and resources from one or the other. In an environment, in which rapid development also requires commensurate and timely mitigation, while the degree of vulnerability of billions of people necessitates robust and immediate adaptation, both issues require concentrated efforts. Planning for each approach in isolation ultimately allows for more efficient and targeted allocation of resources and for greater attention to the requirements of each.

These numerous difficulties in integrating adaptation efforts with disaster risk management or mitigation planning thus mean that we must look elsewhere to identify the paths of least resistance to effective climate-adaptation action. These are likely found in the areas, such as infrastructure and land-use planning, in which planners already have the greatest experience and expertise. To incorporate evaluations of climate risk into such existing planning processes would in fact require little additional capital or capacity. (Susskind 2010). The integration of adaptation with development, rather than with either mitigation or DRM, therefore seems to hold greater promise. Including adaptation considerations in development efforts avoids the need to revamp planning efforts and substantially diminishes up-front expenditures.

EVALUATION OF ADAPTATION APPROACHES

Understanding the various components of adaptation approaches both enables useful comparisons and facilitates evaluation of each alternative's potential value within a given context. Smit et al. (2000) proposed a framework, now widely accepted, for analyzing adaptation options, one that provides a very useful opportunity for a finer-grain understanding of what different adaptation theories do, or do not, address. The authors utilize three questions or "components" to further this analysis: "Adaptation to what?" "Who or what adapts?" and "How does adaptation occur?" In addition to these three components, the framework also provides a basis for assessing "How good the adaptation is" through several criteria: feasibility, scale/level of impact, level of implementability, adaptive costs, and adaptive benefits. Figure 3.2 presents a modified version of Smit et al.'s framework.

Utilizing Smit et al.'s criteria, I have created a diagrammatic evaluation (in Tables 3.1a and 3.1b) of the adaptation approaches discussed in this chapter, in order to assess the extent to which each addresses these three components of adaptation. The analysis suggests that few of these offer any specific guidance in regard to perceived threats, processes, or actors, thereby limiting the opportunity to utilize these constructs for practical and immediate applications. The potential for success of the approaches depends primarily on how closely each specifies the nature of the three components and fulfills the evaluative criteria listed.

However, for an adaptation approach to be effective, it must match well with the particular situation. To evaluate the utility of these approaches, it is thus necessary to comprehend the context within which they would operate. Thus, though Smit et al.'s questions certainly offer a useful mechanism for appraising the components of each adaptation that are discussed previously, they do not provide a framework within which we can evaluate the context-specific applicability of a particular approach.

FIGURE 3.2: Modified diagram of 'Components of Adaptation'
Source: Smit et al., 2000

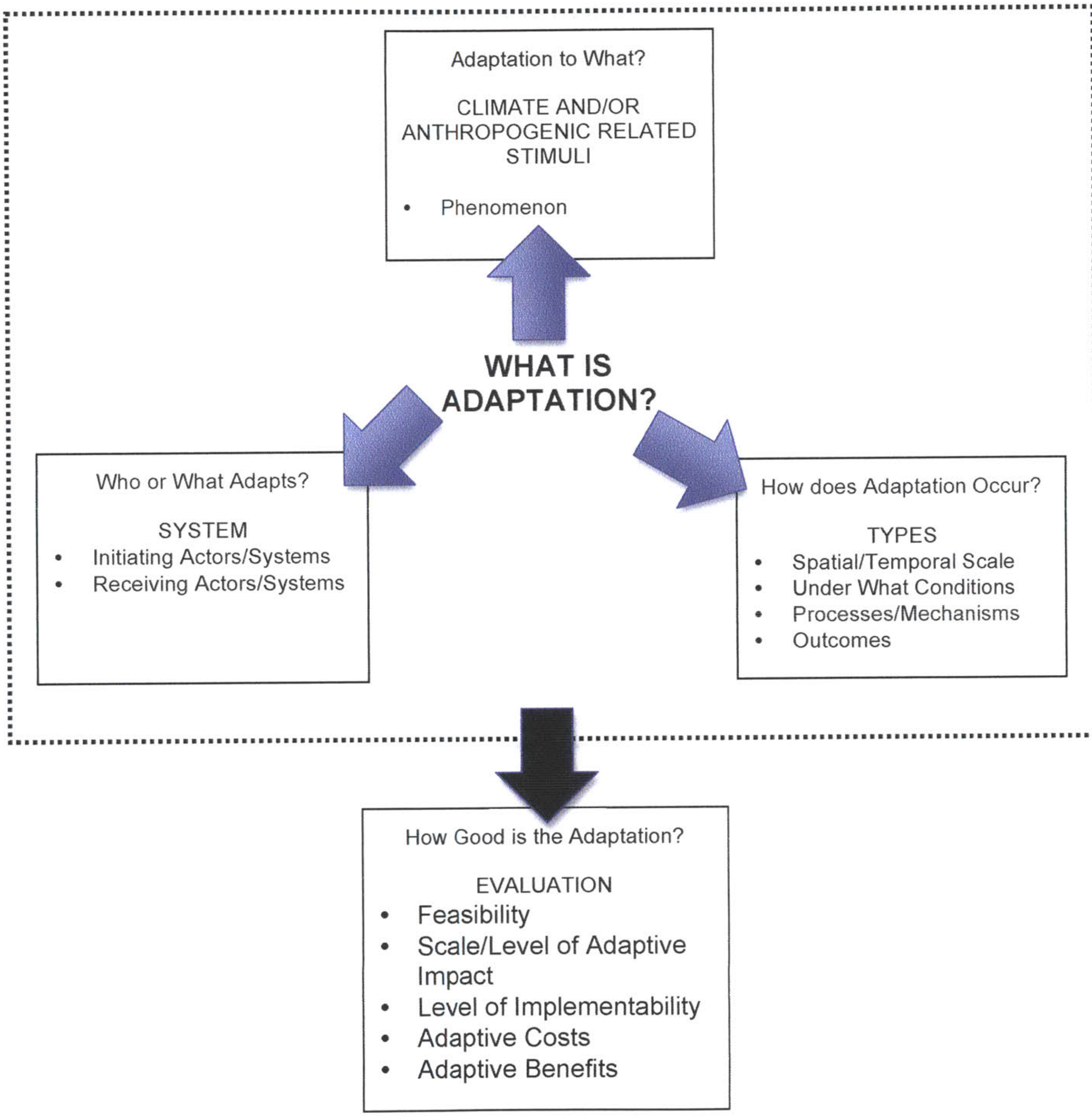


TABLE 3.1a: Components of the Different Types of Adaptations in the Context of South Asian Mega-cities

Types	Adaptation to what?	Who or what adapts?	How does Adaptation occur?
PROCESSES			
No Regrets	☐	☒	☒
Serendipitous	☐	☒	☒
Linked	☐	☒	☒
Transformational	☑	☑	☒
DEVELOPMENT			
Adaptation	☒	☒	☒
Vulnerability Reduction	☒	☒	☒
INTEGRATION			
w/ Mitigation	☒	☒	☐
w/ DRM	☒	☒	☐

LEGEND: ☑Specific ☒ Implied ☐Unstated

TABLE 3.1b: Evaluation of Adaptation Theories in the Context of South Asian Mega-cities

Types	Feasibility*	Adaptive Costs		Adaptive Benefits	Level of Impact
PROCESS					
Transformational	↓	↑	--	↑	↑
No Regrets	↑	↓	--	?	↓
DEVELOPMENT		Initial	Long-Term		
Adaptation	↓	↑	↓	↑	↑
Vulnerability Reductions	?	↑	↓	↑	↑
INTEGRATION					
w/ Mitigation	↓	↑	↓	↑	↑
w/ DRM	↓	↑	↓	↑	↑

LEGEND: ↑ High ↓ Low ? Unknown -- Undetermined

*Feasibility of Action (eg.Local Expertise, Institutional Constraints, Resource Limitations)

Conditions vary widely across the globe, so no single type of adaptation can be universally appropriate or applicable; all are contingent upon context. Apart from Smit et al.'s framework, the literature suggests various other models for selecting suitable types of adaptation based on different sets of evaluative criteria. Though these sets of evaluative criteria are useful in choosing suitable policy option(s), (Smit and Pilifosova, 2001) rightly argue that analyses of "adaptations are essentially normative exercises" that offer only limited aid in guiding planning policy.

Within this milieu of evaluative models, one of the more valuable schema for understanding adaptation processes come from the work of (B. Smith, Burton, Klein, and Wandel 2000). This model, *evaluation of options,* draws upon three principal dimensions: *costliness*, *effectiveness,* and *implementability and flexibility* of the adaptation process.

Within the "evaluation of options" framework, there are two distinct categories of analysis: the first deals with evaluating costs of autonomous and/or reactive adaptations (Tol, Fankhauser, and J. B. Smith, 1998), while the second deals with the evaluation of costs of planned and/or anticipatory adaptations (J. B. Smith and Lenhart, 1996). Though various scholars debate the types of "costs" that need to be incorporated into such evaluations, the consensus tends towards the utilization of both economic and social-cost criteria in conducting the overall cost-benefit analyses. For example, in utilizing both economic and social-cost criteria, Tol et al. (1996) find economic viability, environmental sustainability, and behavioral flexibility to be suitable measures to assess effectiveness of disaster management (in the Netherlands), while they also conclude that strong political will and institutional reform are central precepts to such planned adaptations.

Additionally, other researchers and organizations (e.g., Klein and Tol, 1997: UNEP, 1998) have outlined tools and paradigms for analysis of climate-related planning decisions that utilize prisms, such as cost-benefit analysis, project efficiency, and risk management, displaying strong parallels to the research in portfolio analysis and business management. In the same way that Grissom, Berry, and Lim (2010) utilize the "highest and best use" (HBU) metric to compare development options, planners can incorporate portfolio-based decision analysis into adaptation planning (Grissom, Berry and Lim, 2010).

Though these initial evaluative components of costliness, effectiveness, implementability and flexibility offer a reasonable point of departure, the interpretation of these criteria can vary greatly. Local and regional conditions, including unpredictable climatic impacts, differing degrees of vulnerability and resilience, and level of available resources and institutional capacities, substantially impact planning activities across all of these benchmarks. To qualify these criteria further, several scholars (e.g., Carter, 1996; Smith and Lenhart, 1996; De Loë and Kreutzwiser, 2000) have also proposed additional independent and supplementary criteria. These measures include: whether economic benefits, not exclusive to adaptation, accrue; whether the efforts address high environmental and climatic priorities; whether the planning has long-term benefits for adaptation; and whether the actions reverse or mitigate harmful climatic trends and enhance flexible adaptation. Smith and Lenhart (1996) and Smith (1997), whose work centers on understanding institutional actors and processes, propose *implementability* (financial, technological, institutional) and *assessment of net benefits* (both climatic and non-climatic) as the primary evaluative criteria, complemented by considerations such as a population's risk levels measured against the time frames of adaptations. All these qualifiers offer possible metrics to account for the crucial contextual variances within the broader evaluative criteria.

Academic literature and my own field research demonstrate that South Asian mega-cities face three primary barriers to adaptation. The first is the severity of *resource constraints*, generally of a financial nature. The second is a host of *institutional factors,* which relate to organizational performance, accountability, inter and intra-agency coordination caused by the ambiguities in responsibilities and implementation guidelines as well as deficits in technical capacity. The third is *hurdles to implementation* of such efforts where strong adaptive benefits can be prioritized. Therefore in evaluating adaptation approaches in the context of resource-constrained cities, the broader criteria of costliness, implementability, and flexibility make most sense.[29] In addition, projects that are likely to have both climatic and non-climatic benefits (Smith and Lenhart, 1996; Smith, 1997) are better suited to such contexts; addressing multiple concerns concomitantly is crucial to making best use of limited resources and to increasing the likelihood that these measures will be broadly supported. A

[29] Flexibility in particular is necessary to limit the risk of waste in sunk costs, as with the capital-intensive construction of sea walls that ultimately prove unable to contain rising water levels.

key element of this broad support is that "risk management choices need to be collective choices that reflect the input and support of all relevant stakeholders" (Susskind, 2010: 220). Continuing to focus on economic development—a widely shared value in South Asia—facilitates public acceptance and the political will to carry out such actions. Additionally, in evaluating adaptation approaches, the level of severity of these constraints, the process by and degree to which they are overcome, and finally the overall outcomes (long and short-term) will offer additional insights through which the variances in the broader evaluating criteria (such as costliness, implementability, and flexibility) can be further refined.

SUMMARY AND CONCLUSIONS

To focus on the issue of adaptation in South Asian mega-cities, perhaps the most important questions when proposing a prescriptive and/or normative theory ought to be, "What adaptations are likely?" and "How, and under what conditions, are they expected to occur?" My analysis of the existing theoretical approaches, in the current "landscape of adaptation", suggests a few possible pathways that offer normative applications; their practical scope, however, remains limited, and thus these approaches can offer only limited insights into the issues of climate-related urban planning in South Asia.

Adaptation as Development

The two "adaptation as development" theories discussed above, the "vulnerability reductions" and the "adaptation" approach, though useful conceptually, offer little normative value in the cities examined in this research. Challenges arising from resource, capacity, and political limitations currently impair not only adaptation efforts, but also overall developmental planning in South Asia. To structure an entire new way of planning in which "adaptation becomes the new development paradigm" represents a worthy ideal—not an achievable goal. The adaptation approach thus offers less value for this research. Vulnerability reductions, on the other hand, is a sounder way of approaching climate change planning, insofar as a considerable portion of the current or planned development in South Asia does help reduce the vulnerability of these cities, either directly or indirectly. One crucial weakness for both the adaptation and vulnerability reductions approaches stands out, however: the difficulty of bridging the broad divide between needs and capabilities. The rapid pace of population and geographic growth—the scale of which dwarfs even the existing developmental efforts, not to mention adaptation measures, that are currently underway—further exacerbates this issue. In many ways, resource limitations must serve as the starting point for determining appropriate climate-change action in South Asia.

Nested in these two primary developmental perspectives, two other variations discussed earlier in this chapter, serendipitous and linked adaptation, also pose some of the same problems, as do the adaptation and vulnerability reductions options in terms of conception and implementation. Serendipitous adaptation, which by definition subordinates adaptation efforts, is unlikely to make an appreciable impact on risk levels, while linked adaptation would probably require additional resources and a reworking of the existing planning approaches.

Integration and Transformational Approaches

The integrated approaches—whether between adaptation and mitigation, or adaptation and DRM—again in concept make intuitive sense, in that resources could be combined to address these issues holistically. However, such integrations might shift the focus away from adaptation and, in order for such complex measures to succeed in South Asian mega-cities, much forethought in planning, as well as additional resources, capacity, and expertise, would be required. These factors argue against the broad suitability of such integrative schema, though room for effective coordination certainly exists in some situations. Since adaptation and DRM occur within the same time horizons (and in response to the same stimuli), however, this type of integration offers the better chances for implementation in the long run.

As discussed earlier in the chapter, a process such as transformational planning could serve as a viable blueprint for adaptation, since large-scale "transformations" are certainly necessary to address the formidable vulnerabilities found in South Asian mega-cities. In this region, however, the critical barriers—institutional inertia, ecological and climatic uncertainty, and lack of resources—that affect the feasibility of most adaptation planning approaches would render transformational adaptation efforts even more unattainable. Moreover, reasonable speculation suggests that this type of adaptation would likely be embraced only after the impacts of climate change have achieved a critical mass that threatens survival, not just in anticipation of such a state. Much like the adaptation approach, then, the transformational approach is appealing in theory and may hold great promise for climate adaptation action in developed regions, but it remains a poor fit for South Asia in the current context.

No-Regrets

Conversely, the "no-regrets" approach provides the most useful filter through which to view planned adaptations in this context. In many ways, this approach is ideally suited to resource-constrained environments. However, in the literature, the overall framework for the development and implementation of "no-regrets" remains unclear. What is clear, though, is that the "no-regrets" approach generally accrues certain developmental benefits—and possible adaptive benefits–without the need for large additional expenditures to further such adaptation goals. The "no-regrets" approach probably comes closest to defining a strategy that is tailored to resource-constrained environments. However, other control variables (such as institutional practices or expertise) required to apply this concept to actual planning challenges have not yet been specifically delineated. While "no-regrets" provides a useful lens for development projects, the approach has not yet reached the stage of development where it can be used as a legitimate theoretical foundation for informing practice in the Global South.

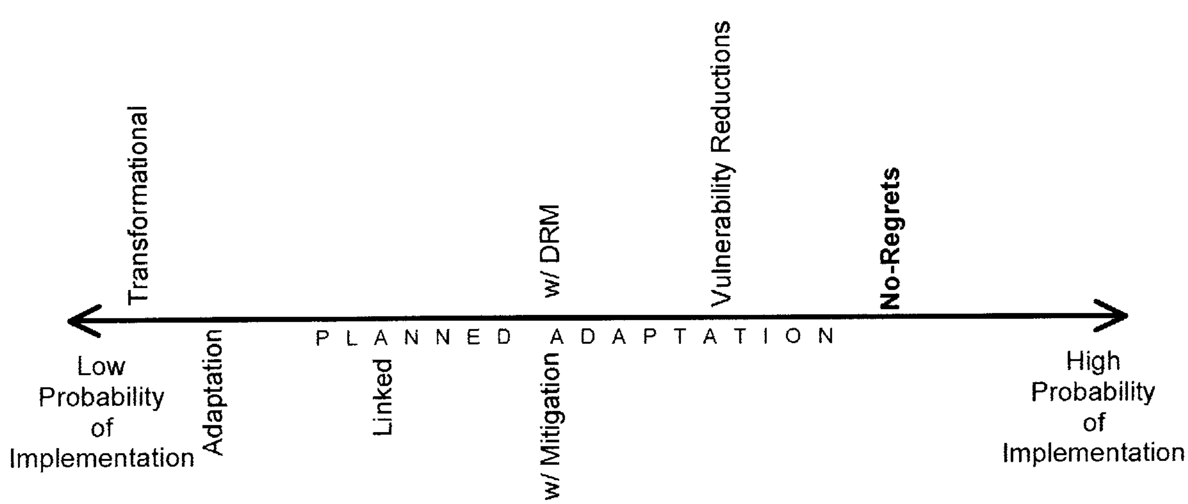
The dominant types of adaptation approaches in the literature tend to cluster at two extremes. On one end of the spectrum, we have comprehensive paradigm shifts, as seen in the adaptation, integrated, and transformational adaptation approaches. Such theories bring serious doubts as to their feasibility—across several criteria—in the context of the Global South, and Kolkata and Dhaka in particular. On the other end, theories such as the serendipitous adaptation and vulnerability reductions approaches generally focus on identifying and securing only incidental benefits. These schemas would likely fail to engender the level of adaptation needed in South Asia.

Three principal concerns thus shape the need for an appropriate option for urban climate adaptation in South Asia. The first is that the policy option for adaptation can only be effective and viable if the response strategies are actually feasible within the region's financial means. In South Asian mega-cities, where resource constraints are perhaps the dominant concern, adaptive approaches have to be able to work within this limitation.

Second, from my survey of the "state of adaptation" in South Asia, described in detail in the previous chapter, I conclude that "formal" adaptation projects have made almost no appreciable difference or gained any significant traction at the city levels. However, in absence of formal adaptation planning, relying upon informal approaches, such as those initiated by communities and other private stakeholders, also falls short of realizing the systemic adaptations that are necessary to address the existing large-scale vulnerabilities. Consequently, one has to situate the evaluation of approaches within the existing systems of governance and planning in order to enable effective implementation, after accounting for lack of capacity and expertise, among other factors.

Third, to provide utility, the approach needs a decision-making framework that not only can be easily understood, but also identifies contextual factors that aid or hinder implementation under different circumstances. Though the no-regrets approach addresses some of these concerns, particularly by virtue of its attractiveness for resource-constrained environments, the theory is not yet sufficiently defined to account for the practical limitations and contextual distinctiveness of the Global South. Given the widespread vulnerabilities and increasing climate impacts in this region, there is an urgent need to formulate an approach that not only accounts for the region's daunting challenges but also advances a more ambitious agenda for climate adaptation in these cities.

FIGURE 3.3: Situating Existing Adaptation Approaches in the Context of South Asian Mega-cities



4

STATE OF ADAPTATION IN DHAKA AND KOLKATA

"To understand the challenge of Climate Adaptation, let me quote John F. Kennedy: There are risks and costs to a program of action. But they are far less than the long-range risks and costs of comfortable inaction."

--Klaus Jacob, Lamont-Doherty Earth Observatory, Columbia University. Chair, Climate Adaptation Group

INTRODUCTION

The gaps in the academic scholarship on adaptation efforts at the city level (Bulkeley et al., 2009; Betsill, and Bulkeley, 2007; Alber and Kern 2008; Lindseth 2004; Storbjork 2007; Zahran et al 2007) may well reflect the reality in the South Asian mega cities; the majority of the academic research likewise points to the lack of attention on adaptation in mega-cities of the developing world (D'Almeida Martins, and da Costa Ferreira, 2011; Yohe, 2012). While mitigation efforts have certainly garnered the attention of city level-governments,[1] "formal" adaptation processes still remain rare. The available reports based on empirical studies or secondary research on adaptation in South Asia also highlight the significant lack of planned adaptation in this region's mega-cities (Campbell-Lendrum and Woodruff, 2006; Masud, 2011; Shah, 2008).

For example, an exhaustive review of "Planned Adaptation Action in South Asia", undertaken by the Adaptation Partnership Consortium in conjunction with the International Institute of Sustainable Development (2011), finds that "little attention appears to be given at present to the particular needs of urban areas with respect to adaptation to climate change." The study looks at eight South Asian countries—Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka. The authors identify many commonalities in these nations' adaptation needs and priorities: water and energy; agriculture; coastal zones and

[1] Some of the cities currently engaging in noteworthy adaptation efforts include Melbourne, Vancouver, Venice, Rio de Janeiro, and New York City. See, for example, D'Almeida Martins, and da Costa Ferreira, 2011; Rosenzweig et al., 2011; Yoye, G. 2012; Jones, 2012; and Munaretto, Vellinga, and Tobi, 2012.

infrastructure; forestry, nature and biodiversity; health; risk reduction; and policy integration. While the study identifies twenty-two ongoing or completed adaptation initiatives at the regional level, which include some pilot projects[2], at the national level, only five of the eight countries have a national adaptation action plan. In South Asia, national-level adaptation plans may sometimes have a strong bearing on local adaptation initiatives for two primary reasons. First, rarely do city agencies initiate any adaptation efforts independently. In cases where they do so, they closely follow or are directed to expand on parts of the national- or state-level adaptation agendas. Moreover, since a majority of these nationally initiated and locally executed projects are externally funded, city governments rarely have an opportunity to prioritize issues or shape their own adaptation pathways. Second, in countries where there is an active engagement with adaptation planning at the national level, as in the case of Bangladesh, city-level agencies are far more aware of this problem and at times also receive greater support from the central government for their own initiatives.

Perhaps unsurprisingly, India, Bangladesh, and Nepal have a greater number of national-level adaptation projects. However, the report finds that the overall number, scope, and scale of the projects remain woefully insufficient to make an appreciable difference in the overall adaptive capacity for the countries (see, for example, Felton et al., 2009). The inherent climatic and social vulnerabilities, which are widespread in these countries, will need systemic attention. Adaptation must become an integral part of the ongoing developmental planning, something that one-off projects are not able to address sufficiently.

It is at the local level, however, where once again, the lack of adaptation planning is most clearly evident. Among the eight countries studied, the Adaptation Partnership Consortium study was able to identify only ten adaptation efforts at the local level across Bangladesh, India, Nepal, Pakistan and Sri Lanka, a region that encompasses over 1.6 billion residents and over forty cities of at least a million residents. Among these ten programs, almost all the initiatives focus on policy research and advocacy and are primarily initiated by private entities such as NGOs, researchers, and civil-society actors. The two government-based efforts

[2] These initiatives are generally conceived and funded by foreign governments or international agencies, rather than by local actors.

(in Bangladesh and Pakistan), which involve local territories, are moreover managed at the national level rather than at the local level.[3]

Like many South Asian cities, Kolkata and Dhaka lack any "formal" adaptation measures. As discussed in chapter two, both cities face severe long-term climatic risks (e.g. from sea level rise and salinity intrusion); moreover, in both cities, extreme climate hazards such as flooding and cyclones are already occurring. In addition, other socio-developmental factors—poverty, very rapid population growth and high density, and deficiencies in water drainage and in sewer infrastructure—will likely also exacerbate the effects of climate change. The potentially devastating implications for the long-term social and economic sustainability of Kolkata and Dhaka make climate adaptation necessary, now more than ever.

Chapter Outline

This chapter is organized into three sections that explore the climate-change policies, actions, and results in Kolkata and Dhaka. First, I examine the current state of flooding and drainage congestion in the two cities. The work then analyzes both current efforts to realize adaptation goals and the challenges that inhere in such efforts. Finally, this chapter analyzes three cases of ineffective climate adaptation projects in depth in order to identify factors that hinder successful planning and implementation.

THE PROBLEM OF URBAN FLOODING

Flood-management efforts across both Dhaka and Kolkata have been widely criticized; the devastation caused by floods over the years in the two cities has become a frequent and widespread occurrence (see chapters 1 and 2). The public outrage against city- and state-level governmental agencies for their failure to address the recurring floods has been thoroughly documented in the local and national media.

For example, in the weeks following the 2007 floods in Kolkata, the television and print media focused on not only the destruction wrought by

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[3] The two governmental efforts identified that have implications for local adaptation are the Indian Network on Climate Change Assessment (INCCA), which focuses on scientific research, and the Technical Advisory Panel on Climate Change (TAPCC) in Pakistan, which primarily advises the National Ministry of Environment on the integration of technical knowledge into policy.

the flood, but also the inadequacies of the government's management of, and response to, the crisis. People were stranded for days on their rooftops waiting for relief crews to reach them, while those who ventured into the water were afraid of getting electrocuted by the submerged power lines. In addition, almost all the major roads were water-logged, which disrupted transportation in the city, while residents lost power and water for up to a full week, largely because of the city's inability to respond to these problems in a timely and efficient manner. Anti-establishment headlines such as "Kolkata still flooded, civic bodies' efforts fail" (Mukhopadhyay, 2007) clearly captured the majority sentiment.

Media reports from the 2004 floods of South Asia were equally alarming. The two major inundations in 2004 claimed a total of 1100 lives (by conservative estimates), with the worst damage and injury occurring in Dhaka, where over 40% of the city remained submerged for several weeks. With the failure of sewage systems and pumps, Dhaka residents complained that they were "living in an open sewer" and that "conditions are getting worse every day as the water is rising bringing in more filth". With most of the initial deaths caused by drowning, lightning, and electrocution from snapped power lines, media accounts reflected prevailing fears of additional deaths due to water-borne diseases and epidemics (Wordsworth, 2004). Despite the widespread devastation, the government at all levels was slow to acknowledge either the severity of the problem or the grossly insufficient official relief efforts. Citizens' comments, ranging from, "the government is still refusing to call for international help saying its own relief efforts are enough," to "several large NGOs have said it should now reconsider [this position]" were frequent comments from the citizens during this time.[4]

Apart from the severity of the actual weather events themselves (cyclones, storm surges, intensity of rainfall), and inadequate disaster-management planning at the city levels, a number of key factors exacerbated the situation. A detailed ward-level analysis performed for Kolkata identified the key causes for the city's extreme vulnerability to flooding (World Bank, 2011). Many of these same risk factors were cited for Dhaka's vulnerability to such urban floods as well (Alam and Rabbani, 2007; Huq

[4] Description and quotations related to the Dhaka floods of 2004 are compiled from various sources, primarily MSNBC, the BBC, and the VOA. Also please visit https://bama.ua.edu/~bsa/flood/floodnews.html_for a compilation of the 2004 Asian flood news.

et al. 2007; Nasra Haque, Grafakos, and Huijsman, 2010). These "adaptation deficits" trace back to three primary causes: *Inadequate infrastructure*, *Overdevelopment*, and *Institutional Weaknesses* (the latter of which encompasses insufficient financial and human resources, planning, and coordination).

The infrastructure problems include deficits in the sewerage and drainage networks and physical capital, inadequate pumping of flood waters (either due to the absence of, insufficient "lift" capacity, or old and/or poorly maintained pump equipment), and low hydraulic capacity of drainage systems (both trunk and secondary lines) due to siltation and collection of solid waste. These structural deficiencies are further exacerbated by the overdevelopment of the cities. This in turn has not only destroyed the urban wetlands, but has also exponentially increased the percentage of paved areas, causing excess runoff, which worsens flooding. In addition, the rate of development in some newly expanded areas has far exceeded the drainage and sewage network needed to sustain this growing population. Some slum areas have no wastewater infrastructure at all, while other areas lie below the pump lines. Lastly, local agencies do not have the sufficient resources to undertake regular maintenance, upgrades and commensurate infrastructural expansion. In addition, inefficiencies and corruption within local agencies (especially in the case of the Kolkata Metropolitan Corporation) not only lead to poor utilization of existing physical, financial, technical, and human resources, but also result in poor coordination of emergency and non-emergency operations (World Bank, 2011).

Apart from the socio-economic and institutional factors that exaggerate the impacts, the climatic risks for such urban flooding in Dhaka and Kolkata arises from two often mutually reinforcing causes. First is the rise of water levels in the peripheral tidal rivers, a phenomenon that is more pronounced in Dhaka. The second is drainage congestion, also known as water-logging, generally experienced during periods of moderate to intense rainfall in both cities.[5] These inundations devastate life and property and disrupt basic urban services (e.g., transportation and access to food, water and health services). Additionally, inadequate waste disposal methods—exacerbated by inadequate and poorly designed storm-water and sewage infrastructure–also contribute to the flood-related

[5] Moderate flooding occurs somewhat regularly during high tides in both cities; heavier rainfall, sea-level rise, storm surges, and river-induced flooding within the context of global climate change all give rise to more severe, debilitating floods.

health hazards. According to Md. A.K.M. Shariful Islam, Sub-divisional Engineer of the Bangladesh Water Development Board and the Assistant General Secretary of the Institution of Engineers, Bangladesh, health concerns are further exacerbated during the floods because household, industrial and septic wastes accumulate or overflow along with the flood waters into low-lying terrain, such as in the khals (canals) and wetlands of the city. These wastes give rise to various debilitating and life-threatening diseases, including cholera, typhus, dysentery, schistosomiasis, malaria, trachoma, and hepatitis (UNICEF, 2012). These overflows result from insufficient low-lift pump capacities and inadequate storm and sewer[6]. This situation is further aggravated because channel regulators to peripheral rivers are shut off during high-water periods as a precautionary measure to prevent riverine flow into the city; such shut-offs, however, also block the outflow of contaminated water. The latter poses a unique problem for Dhaka, which is often threatened by simultaneous riverine floods and intense rainfall. If the city were able to absorb some of the runoff from precipitation through retention ponds and improved drainage systems, water contamination and dangerous overflows would not have been an issue.

Apart from the literature pertaining to flooding in similar cities of the developing world (e.g., Alam and Rabbani, 2007 on Dhaka) , a majority of the interviewees in Dhaka and Kolkata also noted that drainage congestion is recognized as one the most critical causes of urban flooding. For example a senior engineer whom I interviewed at the Dhaka Water and Sewerage Authority (DWASA) said:

> Drainage congestion is right now our biggest problem and we have many projects going on to improve the drainage system...We have not had time yet to evaluate how much of the water-logging will be reduced. We will have to hire outside consultants to do the job [flood abatement evaluation of drainage projects] when we need it.
>
> *(Senior Engineer, DWASA, Dhaka, Interview 32; translated by author).*

[6] In internal memo by Md. A.K.M. Shariful Islam, Sub-divisional Engineer of the Bangladesh Water Development Board and the Assistant General Secretary of the Institution of Engineers, Bangladesh.

Officials in Kolkata expressed similar sentiments:

> Whenever there are rains, we are blamed for the water-logging. What can we do? The systems are very old and now the rains have increased. We are trying our best to repair and de-silt our trunk lines. Also KEIP is working on other drainage improvement efforts. All our time goes in fulfilling court orders [He was referring to the lawsuits filed by several Kolkata residents against KMC for water-logging in the city due to poor maintenance.
>
> *(Senior Officer, Sewer and Water Department, KMC, Interview 67; translated by author).*

However, none of the interviewees was able to provide any information (either orally or in terms of any documented flood-risk analyses) regarding the ongoing planning, implementation or evaluation of drainage congestion measures. The respondents were likewise unable to identify any climate adaptive criteria, such as reducing inundation levels or utilizing evaluations of localized vulnerability, that guide adaptation efforts. The pronounced lack of documentary or first-person evidence regarding any targeted efforts to tackle the problem of drainage congestion suggests that such congestion is more commonly addressed through "regular" infrastructure drainage and sewerage projects. Such projects moreover aim to improve and augment overall development, rather than to enhance adaptive capacity. The only detailed ward-by-ward analysis of vulnerability to increased precipitation of Kolkata was conducted only recently—in 2010-2011—by the World Bank. A senior MOEF official noted in an interview in December of 2010 that "this was the first detailed analysis of this kind conducted for Kolkata" and they "would be doing more".

Moreover, considering the fact that both cities continue to build new drainage and sewer infrastructure using the "combined" system design[7],

[7] Combined sewer systems (CSS) are designed to collect domestic sewage, stormwater, and industrial wastewater in the same pipe. The maximum capacity of these types of systems can be exceeded quickly during periods of intense rainfall, when stormwater enters the system, causing overflow of contaminated water. See, for example, U.S. Environmental Protection Agency (1995), New York State Department of Environmental Conservation (2004), and Gibbons and Yuhas (2005) for a full discussion of the problem of combined systems and of remedies employed in New York City.

which amplifies the likelihood of both capacity breach (overflow) and contamination, adaptive design to counter such Combined System Overflows (CSO) does not appear to be a consideration for such infrastructure.[8] Therefore, such projects designed to alleviate water-logging have not been considered among the "adaptive" projects discussed in this chapter.

In addition to other development-related infrastructure improvements and expansion ongoing in both cities, however, several projects are addressing stormwater congestion, to varying degrees. Despite the maladaptive design of the drainage systems that the two cities are currently constructing, the augmentation of the drainage network in itself is likely to bring incremental relief from water-logging. Some examples of such ongoing projects are provided in the table below. None of the projects listed below have yet been completed, though, and no additional data (actual cost, exact locations, evaluation) were available to assess the "adaptive capacities" of these projects.

TABLE 4.1: Current projects in Dhaka and Kolkata to address water-logging implemented by local agencies
Sources: KEIP, 2012; DWASA, 2013.

Name of Project	Description	Funding	Implemented by
Removal of Water Logging in Dhaka city – Phase II (July 2010-June 2013) Location: Different areas of the city Estimated Cost:	Construction of storm water pipe drains; Road crossing box-culvert; Canal development work	Govt. of Bangladesh (GoB) and Asian Development Bank	Dhaka Water and Sewerage Authority (DWASA)

[8] Many older cities such as New York, with combined systems are still finding ways to adapt to the Combined Sewage Overflow problem. Short of replacing the entire system, NYCDEC (the New York State Department of Environmental Conservation) started a "CSO abatement program" with the NYCDEP (Department of Environmental Protection). Costing $2.2 billion, the project included "the design, planning, and construction of over 30 city-wide projects, including: off-line retention tanks, sewer cleaning, in-stream aeration, floatables-containment booms, skimmer boats, sewer separation, flushing tunnels, vortex concentrators, throttling facilities, catch basin modifications, and numerous other projects designed to optimize the operation of the sewer collection system, pumping stations, and treatment plants during wet weather (New York State Department of Environmental Conservation, 2004).

Insufficient data

Dhaka Water Supply and Sanitation Project (Nov 2008–June 2013) Location: Different areas of the city Estimated Cost: $165.7 million	Sustainable delivery of stormwater drainage, wastewater disposal, water supply for low-income communities, Rehabilitation and strengthening of existing sewerage systems.	GoB and the World Bank	DWASA
Kolkata Environmental Improvement Project (Jan 2002 – present) Estimated Cost: No data Location: Different areas of the city	Various aspects of improving the environmental conditions for Kolkata City which include canal desiltation, augmentation of water supply, wetland managements and improvement of drainage and sewerage systems, treatment plants and pumping stations	Asian Development Bank	Kolkata Environment Improvement Programme (KEIP)

ADAPTATION IN DHAKA AND KOLKATA

As noted earlier in chapter 1, both Kolkata and Dhaka have multi-tier governance structures, which provide direction for climate action. At the city-levels, though there are no specific institutional mechanisms to address local climate adaptation need exclusively, several agencies, however, directly or indirectly manage climate adaptation needs. These local projects, which are often funded by state or national governments or then by international donors such as the Asian Development Bank and the World Bank, and are generally part of the larger developmental initiatives, and do in some cases, fulfill adaptation needs to varying degrees. Table 4.2 below provides a broad overview of the different governmental entities directly responsible for climate action at the state and national levels, local planning agencies in charge of overall local development, climate action plans, city-level plans and funding sources for city-level projects. The section following this table discusses in detail the different elements of this table in further detail for Kolkata and Dhaka.

TABLE 4.2: Kolkata and Dhaka: Institutions, Actions and Funding for Climate Efforts

KOLKATA, INDIA	*DHAKA, BANGLADESH*
GOVERNMENTAL ENTITIES	
National ▪ Ministry of Environment and Forest (MOEF) ▪ Department of Environment (DOE) ▪ National Disaster Management Authority (NDMA) **State** ▪ State Government of West Bengal ▪ Irrigation and Waterways Department (IWD) ▪ Disaster Management Ministry ▪ West Bengal Pollution Control Board **Local** ▪ Kolkata Municipal Corporation (KMC) • Kolkata Environment Improvement Trust (KEIP) ▪ Kolkata Metropolitan Development Authority (KMDA)	**National** ▪ Ministry of Environment and Forest (MOEF) • Department of Environment (DOE) • Climate Change Cell • Climate Change Unit • Department of Forests • Bangladesh Forestry Research Institute ▪ Disaster Management Bureau ▪ Bangladesh Water Development Board ▪ International Adaptation Centre additionally supported by UNFCCC, Danish Government) **State** Not applicable **Local** ▪ Dhaka City Corporation (DCC) ▪ Dhaka Water and Sewerage Authority (DWASA) ▪ Capital Development Authority (RAJUK)
CLIMATE ACTION AND LOCAL DEVELOPMENTAL PLANS	
National Climate Action Plans ▪ India National Action Plan for Climate Change (NAPCC 2008) **State Climate Action Plan** ▪ West Bengal Climate Action Plan (still to be adopted) **National/State Disaster Management Plans/Programs** ▪ National Disaster Response Force	**National Climate Action Plans** ▪ Bangladesh Climate Strategy Action Plan (BCCSAP 2008) ▪ National Adaptation Programme of Action (NAPA 2005) **National Disaster Management Plans/Programs** ▪ Disaster Management and Relief Monitoring Cell ▪ Comprehensive Disaster Management

- West Bengal State Disaster Management Policy and Framework

Local Disaster and Development Plans
- Kolkata Disaster Management Plan (DCC, Kolkata Police, Fire Department)
- City Development Plan
- Sectoral Development Plans

Programme (CDMP) (has local representation for short-term relief efforts)

Local Development Plans
(address key issues such as land use, protected wetlands)
- Dhaka Structure Plan (DSP, 1995-2015),
- Dhaka Metropolitan Development Plan (DMDP),
- Detailed Area Plans (DAPs)

LOCAL FUNDING SOURCES

Agencies
- Government of India (via JNNURM initiatives)
- Government of West Bengal (variuos ministries)
- KMDA
- KMC

Primary International Donors
- Asian Development Bank

Climate/ Disaster Funds
- Bangladesh Climate Change Resilience Fund (BCCRF)
- Bangladesh Climate Change Trust Fund (BCCTF):
- National Disaster Response Recovery Funds
- Local Disaster Recovery Funds (funded by GoB)

Governmental Agencies
- Government of Bangladesh
- DCC
- DWASA
- RAJUK

Primary International Donors
- Asian Development Bank
- The World Bank
- Danish International Development Agency (DANIDA)
- Japan International Cooperative Agency (JICA)

Kolkata

Kolkata enjoys considerably greater resources than do many of the other cities of the Global South;[9] however, the city does not yet have a "formal" local climate-adaptation plan. Though a plan for a city does not

[9] Kolkata, for example, boasts a per-capita GDP about ten times greater than that of Dhaka (WWF, 2009).

necessarily ensure follow-through, and adaptation can be achieved through other planning initiatives, the lack of such a guiding document would certainly indicate that adaptation-oriented planning is not well integrated into its regular planning schema of the city. This is particularly true of South Asian cities, where planning is generally preceded by the formulation of a guiding document (e.g., master plans or sector-development plans).

Disaster Management

The KMC and the Kolkata Police are principally responsible for Kolkata's disaster management activities, which essentially comprise the sum total of the city's current climate-related planning. The city's police oversee field coordination of relief and rescue operations during actual disasters. To guide these city-level efforts to address disaster management, there is also a rudimentary Disaster Management Plan (DMP), a framework that leans towards centralized, short-term relief efforts, rather than towards comprehensive disaster management.

Before Kolkata's DMP was ever actually applied, however, many private citizens, environmental groups, and researchers were skeptical of its potential effectiveness, a belief later confirmed through the "Aila Experience" in 2009.[10]

> When the city said that it had finally created its disaster management plan, we were not sure exactly what they had done, as it was never made public. Like all things the KMC generally does, we felt that it was just for "show" (and done because it was directed by the state government and the National Disaster Management Authority, NDMA). . . And when a real disaster strikes, we will have the same difficulties as we have had before with the city being water-logged for days, trapping all of us [Kolkata residents].
>
> *(Professor, Baligunge Science College (area of expertise: disasters) Interview 94; translated by author)*

[10] In late 2009, in the aftermath of Cyclone Aila, city authorities unveiled plans to upgrade and modernize the city's disaster-fighting equipment and augment the numbers of existing personnel for relief activities.

The Meteorological Department issued grave warnings as of May 21st regarding a cyclonic storm, later named Cyclone Aila, which was one of three storm systems that endangered the city.[11] Originating in the Sunderbans at 120km/hr, the cyclonic storm hit the city of Kolkata at about 90km/hr on the morning of May 25th. Despite the warnings and disaster-management planning that preceded this climatic event, the DMA proved incapable of coping with the severity of the storm impacts. With virtually no effective adaptation strategy, the city was affected by acute scarcities of potable water, and power supplies were continually disrupted for four days. Travel within the flooded city to seek refuge and supplies was impossible because over 3000 uprooted trees blocked a large part of the city center. Aila also caused significant property damage, human injury, and loss of life.

Many newspapers reported that, with tram and bus services suspended, extensive water-logging, particularly in the low-lying eastern parts of the city, and no water or power (to pump groundwater) for days, angry residents blockaded streets and organized huge demonstrations in front of utility offices. The protests continued for more than a week after the incident, with Aila claiming eighteen lives in Kolkata, while city residents feared electrocution from submerged electric lines. One survivor relates the sense of the deprivation:

> We got electricity for only 10 hours Tuesday night after remaining in the dark since Monday. Again the supply has remained disrupted since Wednesday morning. We have not got any water supply since Monday noon. One has to queue up before the tube-wells for hours for a pail of water (*The Gaea Times*, 2009).

The West Bengal Chief Minister, Buddhadeb Bhattacharjee, responded sympathetically to the people's appeals, admitting that the Calcutta Electricity Supply Corporation was incapable of tackling such emergencies at this point.

> In many areas there is no water. Electricity supply is disrupted in the northern and southern suburbs. We are trying our best. I asked

[11] The other two storms were Cyder, which eventually manifested in neighboring Bangladesh, and Nargis, which had disastrous impacts on Myanmar (formerly known as Burma), in which more than 100,000 people died and millions suffered from disease, displacement, and shortages of food and water.

> CESC to increase their manpower including engineers. They have done that partially. But more needs to be done. CESC does not have the experience to tackle such an emergency. So it is taking more time.

Post-Aila, Municipal Commissioner Alapana Banerjee blamed the severe disruptions on the intensity of the disaster:

> It was an unprecedented disaster. We had some preparedness but we could not imagine that it would take such a massive toll. We have to be prepared to control disasters in the future. We have not yet prepared the Detailed Project Report (DPR). However, our consultants have submitted the Preliminary Design Report (PDR). We are verifying it. Once we are done with the verification, we will start preparing the DPR.

Despite the experience with Aila in 2009, as of December 2012, the city government had still not released a revised version of a new disaster management plan; the residents of Kolkata are still unclear as to either how the water supply and power will be safeguarded in the event of another such cyclone, or how water-logging will be addressed. The city has determined that, to revamp disaster management activities, the Fire Brigade of the city, which has been renamed "Emergency Services", will also be involved in future rescue operations. Moreover, the Relief Ministry of the State of West Bengal has been also renamed the "Disaster Management Ministry"; the Ministry now will provide leadership and support for such activities at the city level (Sengupta, 2007).

It is also important to note that, post-Aila, the city has been actively engaged in expanding and repairing the city's water and sewer drainage infrastructure; the adaptive capabilities of these systems are still unknown. However, these efforts have been initiated by the KMC via the Kolkata Environment Improvement Trust (KEIP) more to promote general development than to target adaptation needs in the wake of Aila. In addition, the government of the state of West Bengal has also already invested in, and is in the process of implementing, a number of measures that address siltation of existing drainage channels and expand and repair water supply and sewage infrastructure. Four of these projects have been initiated by the JNNURM, while other key projects, discussed later in this chapter, primarily fall under the authority of KEIP, which is principally funded by the Asian Development Bank (ADB).

The statement made post-Aila by Trinamool Congress Chief and Railways Minister Mamata Banerjee (now the Chief Minister of West Bengal), summed up the situation in Kolkata regarding disaster management:

> The government is virtually non-existent. They don't have any disaster management infrastructure [or explicit policies].

Planning at the City Level

In terms of city planning at the local level, apart from the KMDA and KMC efforts to enhance the city's water, sewer, and drainage infrastructure, measures that address aspects of adaptation, there is also a current City Development Plan (CDP) for Kolkata. The Plan was commissioned by the Government of India's [12] Program and in theory guides the overall strategic development of the city. However, the CDP does not take any long-term effects of climate change into consideration, nor does it outline any explicit adaptation efforts.

> The City Development has [historically] been a way of providing the overall strategy for land-use allocation [schools, residential, commercial] and basic infrastructure [main water, sewer and power lines]. The revised plan is going to provide guidelines for all the parts of Kolkata that are rapidly expanding. Sometimes some of these areas that we are planning for have already been developed and we have to go in after to see how much of it is illegal. As far as what you are asking is concerned [about adaptation to climate change], I am not aware of anything like that. The Disaster Management Bureau [a state-level agency] is in charge of things like that, not the city level agencies [like KMC]
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> *(Senior Officer, Building Department, KMC, Interview 68; translated by author).*

In keeping with the central government's vision of creating economically productive, efficient, and equitable cities, the plan's primary focus is on

[12] The Jawaharlal Nehru National Urban Renewal Mission, or JNNURM, part of the Ministry of Development, is empowered, as per its mission statement, to "encourage reforms and fast track planned development of identified cities. Focus is to be on efficiency in urban infrastructure and service delivery mechanisms, community participation, and accountability of ULBs [urban local bodies]/Parastatal agencies towards citizens" (JNNURM, 2012).

furthering economic development and social justice. JNNURM's guidelines cover issues of land tenure, provision of basic services, economic infrastructure for urban development, and reforms in city financing and governance. Climate-change adaptation remains outside the Program's principal purview, but assuring access to clean water supplies and sewage disposal—an issue tangentially related to climate change—is a central part of the agenda and contributes to overall vulnerability reduction. Of the 111 projects funded to date nationally by JNNURM, sixty-eight have focused on water and sewage, with another thirty-five in roadway construction (JNNURM, 2012). In the city of Kolkata and Howrah, where the latter is part of the larger metro area, 17 JNNURM projects are currently underway which include slum-redevelopment and water and sewage infrastructure projects. While many of them may well have ancillary benefits for climate adaptation, such adaptive benefits are yet to be determined[13].

Apart from the JNNURM-commissioned overall CDP, the city is currently in the process of re-evaluating its sectoral development plans, as well as creating an explicit climate-adaptation plan. According to officials interviewed at the state-level Ministry of Environment and Forests (MOEF) (See interviews 60, 61 and 64), a committee has already been convened and has offered preliminary recommendations. These proposals have not yet been made public, however, and the Ministry has not yet clarified whether the adaptation plan will be exclusively for the city or folded into the larger, state-managed climate-action plan for West Bengal.

> We are not sure yet whether we will need a separate plan for only Kolkata or if having a sector-based plan for the whole state will be more effective. That way each ministry [or department] can be in charge of its own sector [e.g., transportation or power]. We will have to decide what is best and then let city-level agencies know how they should proceed
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> *(Officer, Department of Environment, MOEF, State of West Bengal, Interview 61; translated by author)*

According to the interviewees, the climate adaptation plan for Kolkata[14] will allegedly call for investment in both soft and hard infrastructure in

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[13] For a full list of these projects please see http://jnnurmwestbengal.gov.in/Others/ULB_LIST_Districtwise.htm

[14] Adaptation at the city level is still in its nascent stages and requires considerable

various sectors, including water, drainage, and sewage; the plan also presumably deals with transportation, land use, disaster management, and pollution control needs.[15]

In the same interview, (as noted above), the official also remarked that:

> If you see the draft copy vulnerability analysis report done on Climate Change in Kolkata, we [people of Kolkata] are not really vulnerable, at least for a long time, from sea-level rise and other climate change things that other cities have to worry about. Yes, there has been a lot of rain and some storms, but the problems from those things [water-logging] are more due to poor infrastructure, because the city is growing, than because of climate change

State-Level Climate Action Plan and its Relevance for Kolkata

The direction of Kolkata's Climate Action Plan is in large part reliant on the State of West Bengal. The State has yet to submit its Climate Change Action Plan to the center, however, even though many other Indian states have done so. According to *The Times of India*, the Secretary for the State Ministry of Environment, Mr. Kahlon, notes that the draft plan is "almost" prepared and "now to be submitted.

A review of the "advance" draft copy of this 333-page report[16] indicates that the climate action for the State of West Bengal will be addressed

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guidance. One notable sign of progress comes in the work of ICLEI South Asia, which is working to support the Urban Local Bodies (ULB), including those of Kolkata, and making significant headway in supporting such urban adaptation. ICLEI seeks to drive climate-adaptation action in the KMA region by working with city and district managers in the state to integrate such measures into development activities at the ULB level.

[15] Interview with an officer from the Department of the Environment, in MOEF, Government of West Bengal, December 2010, who asked to remain anonymous.

[16] The West Bengal State Action Plan on Climate Change also mentions the future formation of an autonomous Institute for Climate Change Research & Ecological Design and Management, which will report to the Government of West Bengal and likely be managed by the West Bengal Pollution Control Board (WBPCB). The report specifically notes that adequate funds should be allocated for its functioning and has also selected the various partners who will advise or work with the Institute. This list includes a wide range of stakeholders from many different specialties, including Germany's GIZ (*Gesellschaft für Internationale Zusammenarbeit*, or Society for International

sectorally in the areas of water resources; agriculture; forests and bio-diversity; human health; and energy efficiency and renewable energy. For example, the adaptation strategies for water resources in the alluvial zone, which includes Kolkata (see excerpt of the table in 5), provides many useful adaptation strategies such as to "Limit extraction of ground water" and "Encouraging rainwater harvesting in ponds in farmers' fields." However, the Action Plan on Climate Change does not provide any specific implementation or project guidelines (except for budgets and responsible agencies), or any timelines within which each of these projects will be completed. When asked about how the budget had been allocated for each specific task, the MOEF officer said that it was as per "the calculations of their consultant who prepared the report with input from higher-level ministries" (Interview 64). It is unclear, though, whether the budgetary allocations in the State Climate Action Plan were realistic, since the availability of adequate resources often determines what plans can be implemented. Moreover, without specific project-related timelines, not only the risks, but also the project costs will increase with time, leaving these strategies less effective, with inadequate resources for actual implementation.

Likewise, the policies enumerated in the Climate Action Plan (see next section of same table in appendix 5) such as to "Introduce pricing regulation for use of piped water for domestic use and drinking water" and "Extend compulsory rainwater harvesting regulations for all houses in cities and town in WB", also have substantial merit, especially in terms of advancing adaptation in Kolkata. However, the mechanisms through which these policies can be implemented at the city level have not been outlined. Thus, though the State is aware of the types of adaptations that need to occur at the city level, the Plan lacks sufficient detail to be effective. Additionally, only one chapter (that outlines vague adaptation strategies) is dedicated to urban areas of West Bengal. The rest of the report looks at the statewide vulnerabilities, projections, and impacts.[17]

Cooperation), which has been the primary consultant in formulating this plan. The Institute is envisioned to play a "catalytic role in tracking research being conducted by different departments/institutions/organizations in the state and also undertaking its own" (Govt. of West Bengal, 2012).

[17] The State of West Bengal has actually achieved modest successes in rural efforts devoted to environmental protection and climate adaptation, though its track record in urban areas remains exceptionally poor. See, for example, Deb (2009), for details concerning a somewhat successful experiment in forest management that utilized a multi-level governance structure.

Though the state Climate Action Plan is certainly a big step in the right direction, it is yet to be released or even implemented and moreover does not specifically account for adaptation in its largest and most vulnerable city, Kolkata. Furthermore, as mentioned earlier, the plan provides neither much detail regarding implementation nor any specific timelines.

City-level institutions

Though the ambitions of the KMDA and KMC[18] for the city are somewhat greater than are those of the MOEF—the agency in charge of the state climate action plan—in practice neither agency has made any significant progress (Taylor 2008) regarding adaptation in the city, except for a few projects under the purview of the KEIP. The KMC oversees certain operational and maintenance activities related to adaptation efforts, including sewage treatment and disposal as well as transportation infrastructure. The KMDA in turn (with some additional jurisdictional overlap with other local agencies, including the KMC) leads city-planning initiatives, manages some disaster planning activities, identifies new areas for development, including townships, establishes the city's physical infrastructure, and provides essential water and sewer services.

Though Kolkata is the capital of West Bengal, it does not play an important role in the State's climate-adaptation efforts, despite the fact that it is one of few Indian cities to exercise aspects of strong local governance. The KMC serves as the city's municipal planning authority, though the Corporation lacks sufficient enforcement power to exercise effective control over development. Financial, technical, and jurisdictional constraints, coupled with limited human-capital resources, mean that KMC largely concerns itself with day-to-day management and service delivery rather than with the design or implementation of strategic climate-adaptation measures. Blurred lines of authority and ultimately ineffective attempts at utilizing multi-level governance approaches and overlapping jurisdictions, however, severely complicate the situation in Kolkata.

Although drawing concurrently upon resources, expertise, and authority at local, regional, national, and supranational levels has in certain circumstances proven very effective (Daniell et al., 2011), this approach carries serious risks. Daniell et al., for example, in their study of four such

[18] The KMC covers an area of only about 187 km^2, while the larger metropolitan area, served by other ancillary planning-related agencies, extends to 1854 km^2.

efforts globally, including one in Bangladesh, caution that "mismatches between high level policy-making processes and coordination of local actions for climate change mitigation and adaptation are still common. This is considered to be due to the social uncertainty surrounding local reactions to policy decisions and local stakeholders' interests and impacts on policy creation" (2011: 244), In the context of South Asia, however, national environmental policies are often at odds with local needs (D'souza and Nagendra, 2011), and often translate poorly into local actions (Corfee-Morlot, Cochran, Hallegatte, and Teasdale, 2011). Having additional layers of authority also means greater opportunities for corruption (Davis, 2004). Such a multi-level approach works best when central authorities supply locals with resources, information, and general guidance, while holding city-level actors accountable for results. This approach enables local authorities to "integrate climate change into ongoing centers of urban planning and management...[act] as laboratories of change...[and] work in close proximity with a multitude of key local decision-makers" (Corfee-Morlot et al., 2011: 177). In Kolkata and, to a lesser extent, Dhaka, however, my research shows that central authorities have generally not followed such advice, giving too little importance to urban-centered efforts and too little authority to local institutions. Since cities represent the most effective locus for climate-change action, however, urban areas should be the principal focus of multi-level governance efforts.

Additionally, both the Kolkata Municipal Commission (KMC) and Kolkata Municipal Development Authority (KMDA) are imbued with authority for environmental issues (and thus, to some degree, for climate change), as well as for overall master planning. However, the multiple, overlapping areas of responsibility that complicate policymaking, implementation, and enforcement of climate-change initiatives, at all levels of government, greatly hinders such efforts. Interviewees indicated that the two agencies worked poorly together in practice, failing to capitalize on their respective areas of competence. The result is often a lack of clear accountability, with initiatives "falling between the two stools" of KMC and KMDA (Interviews 69, 70, 71, 73, 79 and 80). Where responsibilities have been apportioned, there is often little logic or strategy in how this occurs, as for example in the division of authority for the city's twenty-seven pumping stations (discussed in greater detail later in this chapter), for which the

KMC, KMDA, and three other agencies are responsible.[19] The lack of proper plan implementation and inaction resulting from the overlapping responsibilities among city agencies in Kolkata are captured in a summary of July 2012 report on a Public Interest Litigation (PIL) lawsuit filed against the city agencies. A prominent environmental activist, Mr. Suhas Dutta, brought Public Interest Litigation before the Calcutta High Court claiming governmental mis- and malfeasance regarding water-logging According to the accusations in the lawsuit, with which the Court agreed, much of the city's water-logging problem stems from the failure to implement the 1966 Drainage Master Plan, which had been jointly prepared by the State Government and the World Health Organization. The PIL also focused on lapses in essential maintenance and oversight that severely worsened the city's flooding problems, as "the stormwater channels and canals to drain out accumulated rainwater have not been de-silted and are beset with encroachments" (*The Statesman*, 2012a). The PIL further alleged that the principal cause of these deficits is the lack of coordination between the different agencies, including the KMWSA and the fisheries and irrigation departments of the government of West Bengal. In an affidavit responding to an earlier lawsuit (2007), the KMC had already admitted that poor coordination and irrational division of responsibility among city agencies represented primary barriers to its effective administration. The 2007 lawsuit, which came in the wake of yet another serious episode of water-logging in the city after a torrential downpour, did not effect any positive outcomes, except that the KMC produced an Action Report to remedy the situation. The steps enumerated in the Action Report, however, were never implemented. After the most recent PIL, the Court directed KMC, the Kolkata Metropolitan Water and Sanitation Authority (KMWSA), and the state fisheries and irrigation departments to prepare a report on how to address these shortcomings in light of the original Plan and changing conditions.

Such organizational failures are compounded by the relatively unchecked patterns of development that characterize the city. Despite the gravity of the numerous climate threats facing Kolkata, the municipal authorities

[19] The KDC manages sixteen of the city's pumping stations, and the KMDA oversees another; the Irrigation and Waterways Department (IWD), West Bengal's Public Health Engineering Department, and the Calcutta Metropolitan Water And Sanitation Authority (CMWSA) have authority for the rest. No rationale based on expertise, geography, or funding concerns explains this patchwork of responsibility.

have taken a hands-off approach to development, fully prioritizing opportunities for economic growth (and graft) at the expense of long-range sustainability. This shortsighted approach is captured well in a 2012 report. The Parks and Gardens Department of the KMC as well as the State-level Forest Department's Urban Recreational Forestry wing were severely criticized for their incompetence in maintaining some of the most prominent parks and lakes of the city, including the Subhas Sarovar in Beliaghata and Rabindra Sarovar in Tollygunge. While the KMC officials claimed to be "overworked", under-staffed and ill-trained, the Forest Department officials, which has a staff of 450, among them four horticulturists, claimed that the maintenance was "not in their work descriptions". The lack of coordination at the city level extends to the executive branch as well. To date, no member of the Mayoral Council has even attended any meeting of the Kolkata Metropolitan Planning Authority's Environment Cell, for instance (Bandyopadhyay and Ray, 2012).

Kolkata hence faces many of the same challenges as other South Asian mega-cities in designing and implementing effective adaptation strategies. The rapid rate of urbanization—intensified by the influx of climate refugees, the city's economic upturn, and the need to provide basic services—makes preparing for exposure to extreme climatic threats, such as cyclones and flooding, a difficult endeavor. Addressing these challenges is further complicated by the complex institutional arrangements outlined above, which lack clarity in overall strategic vision and in the division of responsibilities.

Private Activism

In assessing the state of adaptation at the city level, it is important to note that, although the city government lacks urgency in leading adaptation actions, private activism is this arena has gained considerable momentum. As the risks for Kolkata to climate change are becoming more obvious, manifesting themselves in areas such as frequent urban flooding, the city's residents have correspondingly demonstrated greater awareness of their own need to respond to these threats. Climate-change awareness campaigns and actions remain largely limited to non-governmental sectors, where environmental activists, community groups, NGOs, universities, and businesses seem to be filling the void arising from governmental inaction. Kolkata's civil sector demonstrates the residents' recognition of the potentially disastrous impacts from climate change in a variety of ways. The media have kept constant vigil on this issue, reporting on the state and local governments' failures to take substantial action; many other private efforts[20] likewise testify to the widespread urge to address this problem.

A current, unique campaign to raise consciousness of climate issues in Kolkata is also worth mentioning, especially because it capitalizes on the city's large population and high density. The campaign's champion, Mr Kallol Roy, an environmental activist who is considered one of the climate leaders of India, spends every first and third Sunday of the month creating climate awareness, in the busy railway station of Barrackpore, where he has access to thousands of commuters in a span of few hours.[21]

Dhaka

Currently, Dhaka's climate-adaptation efforts are largely dependent on Bangladesh's national plans and policy frameworks. Unlike the State government of West Bengal, however, Bangladesh's national government has been proactive in establishing (and, to an extent, implementing) climate-related strategies.[22] Though many of these efforts are at the national level, relatively substantial resources and numerous planning

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[20] Many private campaigns promote climate-change action in the city. In 2009, for instance, the Kolkata chapter of the NGO "Cap the Gap" organized a major procession in the city to increase climate awareness. The rhetoric of this demonstration, though focused on mitigation-oriented emission reductions, nonetheless confirms the public's broad concern. The procession, one of the largest of its kind in the city, drew many environmental organizations, businesses, media entities, and students. Many similar events inspired by the work of "Cap the Gap" have followed, most recently the "Green Run" in 2011. Organized by a prominent hotel chain and the Athletic Coaches Association of West Bengal, a thousand local athletes, along with many other private citizens from surrounding areas, participated in the 15km run to emphasize the dangers inherent in global warming in Kolkata, as evinced by the fact that the ten warmest years in the city's recorded history have occurred in the past one-and-a-half decades.

[21] For a full audio report of the campaign, including a brief interview with Mr. Roy, please visit:
http://www.bbc.co.uk/worldservice/news/2009/11/091111_eight_centres_kolkata.shtml

[22] Bangladesh was one of the first countries in the South Asian region to participate actively in the UNFCCC process. The country developed its National Adaptation Programme of Action (NAPA) in 2005, subsequently adopting the Bangladesh Climate Change Strategy and Action Plan (BCCSAP) in 2008, a framework that will serve as a "live" blueprint for climate-change adaptation within the country through 2018.

initiatives support many vulnerable parts of rural Bangladesh as well as measures to "climate-proof" Dhaka (as in the case of the country's Flood Action Plans, discussed in detail in the next chapter).

Mechanisms for Climate Adaptation

The Ministry of Environment and Forests (MOEF) coordinates closely with the United Nations Framework Convention on Climate Change (UNFCCC). Several separate agencies fall under the MOEF, designed to facilitate its management of environmental and natural resources:

- Climate Change Unit (established 1989)
  (The CCU works in conjunction with the National Planning Commission to integrate climate-change perspectives into local planning measures and nationwide development plans.)
- Department of Forests
- Department of Environment (established 1989)
- Climate Change Cell (established in 2010)
  (The CCU oversees the Department of Environment's allocation of resources and authority for the implementation of the Climate Change Trust Fund.)
- Bangladesh Forestry Research Institute

In 2011, in collaboration with the Danish government, Bangladesh also established an International Adaptation Centre in Dhaka with support from the UNFCCC. The central government has implemented other proactive measures to adapt to climate change, including the Bangladesh Climate Change Resilience Fund (BCCRF)[23], constituted in May 2010, which now has about $125 million in grants to increase overall resilience. The primary purpose in creating the BCCRF is to guide the nation's Climate Change Strategy and Action Plan from 2009 to 2018.[24]

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[23] Established as a primary partnership between the World Bank and the Government of Bangladesh, the fund has also received contributions from numerous governments, including those of Denmark, the European Union, Sweden, the United Kingdom, and Switzerland.

[24] Apart from the widely publicized efforts of the BCCRF, the government is also planning a series of independent funds that can be utilized for disaster response and risk reduction The National Disaster Response Recovery Fund and the National Risk Reduction Fund, both of which are currently in the planning stages and for which the government is seeking international donors, will augment the already established Local Disaster Recovery Funds. Additionally, the central government has mandated that relevant

While the BCCRF is one of the first "climate exclusive funds" to be established by any of the countries in this region, its reliance on central government financing means in practice that national politics dominate its operation, however. [25] When asked how the BCCRF is currently contributing to Dhaka's city-level adaptation, some interviewees from the Dhaka City Corporation (DCC) and Rajdhani Unnayan Kartripakkh (RAJUK)[26] (interviews 34, 35, 37, 38, 41 and 42), noted that "to the best of their knowledge" the BCCR funds have until now, never been used for any specific adaptation efforts for Dhaka:

> We have no control over those funds. All the decisions as to where the money should go are made at the Center and they never consult with us. Mostly, all the foreign agencies [like ADB and the World Bank], provide advice and the government has their own consultants who are "foreigners"
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> *(Officer, Dhaka City Corporation, Dhaka, Interview 37; translated by author).*

> If you ask me, there are many problems that Dhaka faces. Flooding and the water-logging have become very extreme. We have to do something about this as soon as we can. Our company [DWASA] is currently working on this and we hope that there will be some good results. Some of this [the money] should come to us [the local agencies] --- we have many drainage projects that we need to work on to reduce these problems . . .
>
> *(Officer, DWASA, Interview 29; translated by author).*

The responses of these local officials testify to the difficulty of realizing even well-planned, strategically focused national initiatives on the local

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ministries and departments make provisions to allocate funds designed to further programs outlined in the Disaster Risk Reduction (DRR) section of the nation's Sectoral Development Plans (Government of Bangladesh, 2010).

[25] The BCCRF operates principally under the purview of the Bangladeshi federal government. In concert with the national government and the BCCRF's international development partners, the World Bank is currently overseeing the Fund's financial management—primarily to ensure transparency and accountability for the donors—and providing organizational expertise to enhance the efficiency and effectiveness of the Fund's projects.

[26] RAJUK replaced the Dhaka Investment Trust and serves as the Capital Development Authority of Bangladesh.

level. Apart from these funds and programs, as mentioned earlier Bangladesh also established a Climate Change Cell[27] in 2004, which operates as a unit of the national Department of Energy. The Cell operates somewhat autonomously; its primary role is to manage and coordinate climate-change-related work in the country. The Cell engages in the capacity-building of professionals, practitioners, and policymakers and enables stand-alone public and private climate-focused projects through various mechanisms, including funding and information-sharing.

The officers I interviewed at the Climate Change Cell and Climate Change Unit, provided a different perspective on how the National Climate Change Funds were being used than did the city level officials of DCC and DWASA.

> We provide funds [those that are controlled by the Bangladesh Government for climate change initiatives] depending on the merit of the project, not because it is a city-level agency or national ministry or department. We even provide funds to academics and researchers if they have a project which will help with adaptation...We generally do not provide funds for development projects such as infrastructure for water supply or drainage [like those that DCC and DWASA currently implement]
>
> *(Director, Climate Change Unit, Government of Bangladesh, Dhaka, Interview 3; translated by author).*

When asked about the specific climate-adaptation projects for Dhaka that had been recently completed and funded on the national level, the Buriganga Cleaning Project was cited as a successful measure that fulfilled the environmental criteria identified by the CCC representative.

Another interviewee, however, who asked not to be identified, pointed to the ways in which political considerations influence the selection of projects to receive national support:

> To tell you the truth, the projects that are chosen first are the ones which come from the Minister's recommendations. The Buriganga Project was more of a beautification project than for adaptation. The scope of the project was to remove polythene bags from part of

[27] Political stakeholders are entertaining the idea of transforming the Climate Change Cell into a full-fledged Department and/or Ministry in the near future (Interview 10).

> the Buriganga river that flows through Dhaka, as this was adding to already big problem of siltation and also creating a "bad smell" in the city
>
> *(National agency representative, Bangladesh Interview 2; translated by author).*

When asked whether the project was a success, the interviewee shed light on problems arising from blurry lines of responsibility and from inadequate evaluation procedures:

> Though we said the project was a success because it was implemented and completed, there was no way to stop people from dumping garbage into the river after that. There was no monitoring after the project was done. Since the city was not in charge and the agencies working on the dredging and cleaning were gone, nobody was responsible anymore. But Dhaka city has since banned the use of polythene bags, which is a very good thing
>
> *(Representative, Climate Change Cell, Government of Bangladesh, Interview 8; translated by author).*

Dhaka's Limited Role in Disaster Management

Most projects intended to address adaptation goals operate as sub-programs of the Comprehensive Disaster Management Program (CDMP).[28] The CDMP and general disaster-management efforts for the country are principally under the purview of Government of Bangladesh's Disaster Management Bureau, which consists of representatives from various agencies and ministries of the national government. The Bureau also has a technical division, known as the Disaster Management and Relief Division (DMRD), which offers disaster-specific guidance. As detailed in Chapter 2, in Dhaka, Dhaka City Corporation's Disaster Management Committee (DMC) [29] serves to facilitate institutional collaboration. The Standing Orders on Disasters (SOD), formulated by the

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[28] In addition, the Bangladesh Armed Forces Division (AFD), in consonance with national initiatives, has devised a contingency plan for the city of Dhaka that includes provision for a "Disaster Management and Relief Monitoring Cell" in the event of a natural disaster, a plan primarily targeted at responding to earthquakes.

[29] The Dhaka City Corporation's Disaster Management Committee (DMC), led by the Mayor, consists of fifteen other city-level officials representing the police, the health directorate, and the agriculture, water, and electricity boards, among other agencies. There is also an NGO representative who is nominated by the DCC.

DMRD in conjunction with other national agencies, not only enumerates an explicit policy for district-level collaboration during disasters but also provides for a Disaster Management Committee at the city level.

Though such formal institutional arrangements exist, principally where natural opportunities for collaboration on adaptation efforts between the city and the center via the Dhaka DMC, the Bureau's actions are not effectively coordinated with the adaptation or planning efforts of the city agency, except during emergencies in Dhaka (DMB.gov, 2012). However, though the extent of such combined efforts is not optimum and coordination of adaptation and DRM efforts for normal development activities remains very infrequent, even this minimal collaboration among local and national authorities is somewhat greater than that in other institutional arrangements found in Dhaka and Kolkata. Capitalizing on such existing institutional overlaps and synergies, in which local and national agencies jointly execute projects through the direction of one agency (in this case the Disaster Management Bureau), can open pathways for other such collaborations.

City-Level Adaptation

At the city level, the progress in adaptation planning has been less favorable. Though Dhaka is the country's economic, political, and cultural center and is relatively prosperous compared to the other cities of the country, it has yet to make any great strides in formally integrating adaptation into its development plans. Moreover, the city still lacks a city-specific adaptation plan or disaster-risk management plan and has failed to capitalize on existing institutional frameworks, such as through the Dhaka DMC, to work together with the national government on adaptation activities.

In Dhaka, what local authority exists, resides primarily the Dhaka City Corporation, whose structure is very similar to that of the Kolkata Municipal Corporation in Kolkata. The other local governmental agencies include Dhaka Electricity Supply Company (DESA)[1] and various line ministries, (e.g. Land Administration, Public Works, Education and Health); the two major city-level planning bodies are the DCC[1] and RAJUK. Dhaka's WASA (Water Supply & Sewerage Authority) meanwhile is responsible for a majority of the planning, infrastructure development and maintenance of water supply, sewerage, and drainage facilities for both Dhaka City and the neighboring area of Narayanganj. Like the KMC, the DCC also reports directly to the elected mayor of the city; the commissioners[30] of both Corporations are elected officers as well, which is a key measure employed in both cities to institute at least the semblance of a democratic framework within city-level governance.

The legal framework and jurisdictional authority for the DCC have developed somewhat haphazardly ever since its establishment in 1990; this municipal body thus suffers from limited authority and effectiveness in implementing plans and discharging its regular functions. These difficulties are exacerbated by the resulting unclear division of responsibility and authority among various city-level agencies, diminishing accountability for the city's residents, as Sadiq Ahmed, Vice Chairman of the Policy Research Institute of Bangladesh, has shown (2010). Moreover, constraints on financial and human resources and lack of technical expertise, when coupled with these jurisdictional problems, mean that the DCC concerns itself with day-to-day management and service delivery rather than with design or implementation of climate-adaptation measures, much like the situation of Kolkata's KMC (Huq and Alam, 2003). The lack of financial autonomy[31] and severe resource constraints[32] remain the most significant challenges for the DCC and greatly hamper its functioning. The disproportionately low city budget, of which only 41% is generated from the city's own revenues, represents less than 0.5% of the city's GDP and less than 2% of overall public spending in the country.[33]
Compounding the challenges of Dhaka's inherently precarious

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[30] The DCC, like the national government, possesses a highly centralized structure, with the Mayor serving as both the agent of the ruling party and the final authority on issues of funding and policy.

[31] 59% of total municipal expenditures in Dhaka come from the central government, in the form of capital transfers and grants, underscoring the lack of independence, and thus autonomy of action, for the city.

[32] Sources of funding for the DCC, outside of government allocations, include property taxes, rent from commercial properties owned by the entity, merchant and vehicle fees, and advertising and entertainment levies.

[33] According to Transparency International's Corruption Perceptions Index (2010), Bangladesh continues to rank very low, regarded as one of the most corrupt nations in the world. The corruption likely reaches even the highest levels of government. In 2012, the World Bank cancelled a $1.2 billion loan for the construction of the urgently needed rail and road bridge project across the Padma River precisely because of concerns regarding extensive graft and inadequate financial controls.

environmental situation is the urgent need to plan for a still-expanding population for a city of over fourteen million that was originally designed to hold only one million. Many of the fragile wetlands and basins around the city have been converted to residential use, further aggravating problems of groundwater depletion and subsidence. This environmental degradation is occurring despite the fact that the Dhaka Structure Plan (1995-2015), part of the Dhaka Metropolitan Development Plan (DMDP), does offer both guidelines for sound land-use and specific directives for conservation efforts. The DSP's mandates also include the construction of retention ponds in order to collect rainwater and limit inundation, and the prohibition of additional development in designated low-lying areas to ensure efficient water drainage. Lack of enforcement of the DSP nonetheless renders this instrument rather ineffective. Moreover, most of Dhaka's formal city-level adaptation and disaster-management efforts are shared by several different agencies and administered through multi-level governance structures, an approach that has proven unwieldy and ineffective in regions with less transparent or ineffective governance.[34] In spite of these barriers, the latest Dhaka Spatial Plan prepared by the Dhaka City Corporation with relevant input from the CDMP, does contain detailed maps of shelters, evacuation routes, procedures, policies, and personnel organization of Dhaka City in the event of any city disasters.

Grassroots Efforts and Private-sector Leadership

Despite relatively weak adaption efforts at the city level, grassroots action in Dhaka has focused on community-based adaptation, a strategy that international climate experts argue has the potential to significantly improve the quality of life for the country's poorest residents. Such a bottom-up climate-response framework emphasizes the human dimensions of urban planning, an approach that has proven quite successful in conditions of severe technological and resource limitations, as is the case in Dhaka. Similar community-level initiatives in agricultural management and water conservation have made admirable progress in other regions of Bangladesh as well (Daniell et al., 2011).

Several initiatives that rely on private-sector leadership have also

[34] Several recent studies, including Mirumachi and Van Wyk (2010), have demonstrated that multi-level governance structures, though designed to encourage broad participation of local stakeholders, in effect often result in highly centralized, bureaucratic processes due to the "empowerment disparity" between central authorities and local agencies or stakeholders.

effectively mobilized broad support for climate-change action. In the Chanda Beel Golpangonj region in Bangladesh, another community-based project succeeded in diversifying aquatic resources, increasing employment, and conserving endangered species while protecting fragile floodplains (Hussain, Chowdhury, and Jabin, 2005). Other efforts, such as the seasonal relocation of farm workers during flood times coupled with innovative multi-cropping techniques in the growing season, have produced encouraging results. In the Southwest of Bangladesh, various coordinated actions, including planting mangrove fields to strengthen riverbanks against flooding and introducing integrated agricultural production, combined with expanded environmental education programs, have had measurable positive outcomes for conservation and climatic adaptation (Islam and Ullah, 2012). Yet another example of adaptation can be seen in the rural villages of the Sunderbans in southwestern Bangladesh, where the residents have successfully diversified their livelihoods. Whereas previously, rice farming had served as the primary means of sustenance and employment, increased flooding, saltwater intrusion, and storm activity have made this type of cultivation less productive; consequently, the residents have turned to cash-based aquaculture, predominantly shrimp farming, to survive (Anik, Khan, and Sayed, 2012).[35] This shift, however necessary, has led to decreased overall employment levels, since shrimp farming is less labor-intensive than is rice farming, as well as to higher food costs, and thus more widespread landlessness, indebtedness, and poverty. The gradual switch to crab farming, which is both more labor-intensive and suitable to a high-salinity environment, has restored a greater economic balance to the area, though (Hamid and Alauddin, 1998).

"DOING MORE WITH LESS"

Dhaka's relative success compared to other, more prosperous cities of the region seems to contradict the conventional wisdom that the extent of climate adaptation most strongly correlates with development levels and resource capacity. There are a few distinct reasons that make this possible. Within the political arena, the impetus for such action comes from two other driving forces, the *government's commitment* as well as *political champions* for climate change within the central leadership.

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[35] The authors identify several autonomous adaptation practices, including "crop diversification, floating garden[s], duck rearing, cage aquaculture, wave protection walls, re-digging of canal[s] and construction of embankments", as particularly high-value measures (880). Some of these measures would also be of value in parts of Dhaka.

Additionally, the political landscape has created a space for *new institutional configurations*, which have facilitated the planning process and subsequent implementation. Moreover, adaptation has been widely undertaken at the grassroots level (autonomous adaptation); *innovative use of existing resources* has aided adaptation efforts. Lastly, greater *perception of the level of climate risk* and its potentially devastating consequences, some of which are already occurring, has also spurred the country into action.

Political Commitment and Champions

One of the biggest reasons for the relative success in advancing the climate-change agenda in Bangladesh has been the progressive shift in attitudes of the central government. According to Alam et al. (2011), this shift has occurred through roughly three discursive stages over the past decade. In its initial stages, the political parties were skeptically evaluating climate change as "yet another international agenda." Fuelled by NGOs, media and the growing sentiments to affect real change through the actions of the national government, this discourse evolved to become a "justice discourse." This was reflected in Bangladesh's strong position at the COP15 negotiations, in which the country wanted to protect its interests as a least developed country (LCD), "based on the principle of compensation, right to access funding, equity and national control over adaptation resources" (Alam et al., 2011). From the justice discourse emerged yet another important understanding, that climate change should be seen as a development issue (given the country's LCD status), so effective climate-change action requires both climatic and non-climatic drivers within the planning processes. The increasing awareness of climate issues has also been catalyzed and sustained by *international donor* attention, technical support, and (actual or expected) funding, as well as by the total foreign aid the country has received and the multinational political focus on global warming.

Climate-change adaptation has had its fair share of political champions as well, among them the current Prime Minister of Bangladesh, Sheikh Hasina, daughter of the nation's Founding Father, Sheikh Mujibur Rahman.Hasina is currently the head of the majority ruling party, the Bangladesh Awami League, and came to power for a second term, after seven years in opposition, in 2008. Under her leadership, climate-change concerns have increasingly risen to the forefront.[36] Progressive measures

[36] Some of the Prime Minister's central priorities have been environmental issues,

in this sector include the establishment of the Bangladesh Climate Change Resilience Fund (BCCRF), funded by the central government with support from external donors. Hasina also recently personally represented Bangladesh at the international Climate Week Conference convened in New York City in 2012, lending credence to her rhetoric on addressing global warming.[37] In the interviews that I conducted with officials of the Ministry of Environment, the respondents also spoke positively about the support of the political leaders. An executive director at the MOEF also added that:

> We have a lot of senior officials who know the importance of climate change and want to make a difference and have been educated abroad. One of those most prominent persons is our Honorable Minister [of MOEF]. He[38] has several degrees in environmental sciences and is very committed to the cause and very supportive
>
> *(Senior Official, MOEF, Government of Bangladesh, Interview 9; translated by author).*

The central government's commitment to climate-change issues has also had a trickle-down effect among several city-level agencies in Dhaka. This is particularly evidenced in the widespread awareness of climate-change adaptation and the role of developmental planning in achieving adaptation. In stark contrast, none of the city-level officials whom I interviewed in Kolkata was able to articulate the concepts of climate change or adaptation, let alone relate these ideas to the work of the agency. The only officials in Kolkata who were aware and informed about the subject

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especially water-sector concerns. Shortly after taking power, the Hasina government concluded an agreement with India to divide water from the Ganges more equitably. Since India completed the Farakka Dam, just ten kilometers from the Bangladeshi border, in 1976, flow into Bangladesh has slowed considerably. Under the agreement, Bangladesh was to receive 33,000 ft^3/second (930 m^3/s) of water.

[37] Bangladesh belongs to the Climate Vulnerable Forum, which consists of developing nations threatened by climate change (Goossens, 2012).

[38] The Senior official was referring to Dr. Hasan Mahmud, who is regarded widely as a political champion for the cause. He has several degrees in human ecology and environmental sciences, including a PhD in Environmental Chemistry from Limburg University in Brussels. For further information on Dr. Mahmud's views please see his interview at COP16 http://cdkn.org/resource/cdkn-in-conversation-with-dr-hasan-mahmud-bangladeshi-minister-of-environment/.

were senior officials at the Ministry of Environment at the State level. In contrast almost all the city, state and national officials that I interviewed in Dhaka were well-aware of climate change, able to identify the larger risks, such as sea-level rise and floods, to which Bangladesh is vulnerable ,and cognizant of the urgent need for adaptation.

> Of course we are aware of our problems [from climate change]. How can we not be—people are dying! We have so many conferences about it and our ministers [at the center] are actively involved in this cause. In Dhaka city, our biggest challenge is population. We have to provide safe drinking water to so many people. It is not an easy task, but we have the support to move forward
>
> *(Senior Official, DWASA, Dhaka, Interview 33; translated by author).*

New Institutional Configurations

Bangladesh has undergone significant changes in its institutional landscape in the past decade. Much of this change has been stimulated by the country's new focus on addressing climate-change concerns. For example, these institutional changes can be seen at the highest levels of government, where for example in 2008, an all-party Parliamentary Group focused on such issues formed, as did a committee of MPs who represent coastal districts. The formation of the Climate Change Cell and the Climate Change Units within the Ministry of Environment and Forests represented another such sector. Non-governmental stakeholders, from activists to academics, also got involved in efforts to set ambitious policy agendas.

Moreover, these institutional changes were characterized by new types of organizational configurations, where many of the newly formed governmental agencies were established as semi-autonomous units, in a large part to overcome the inherent bureaucratic delays, avoid political conflict and to be able to work independently on their very specific agendas. A few key semi-autonomous agencies that can be considered demonstrative examples of this change were the Climate Change Cell and then more recently, the Climate Change Unit in 2010. These agencies, though nested within the MOEF, had significant authority and autonomy to work on and implement their own programs.

Another unique factor that increased the success of such semi-autonomous institutions was the large influx of international funding, which provided the much-needed external stream of resources for these agencies to work independently and at times without undue political influences. This international funding stream was a result of a few key policy changes among donor institutions such as the ADB and the World Bank. During this time, climate change also became an important criterion in disbursing developmental assistance; hence developmental projects, which also addressed climate change, were being increasingly funded.

In the case of Dhaka, this new type of institutional configuration is exemplified in the changes in DWASA. As explained in detail later in this chapter, DWASA now models itself after an autonomous private entity where it not only formulates and implements its own plans, but also sets its own budgets. Moreover, the "company" has achieved financial autonomy through institutional innovations in areas such as service delivery and revenue collections. In addition to such internal resource enhancements, DWASA has also partnered with international agencies , including DANIDA and the ADB, to tap into additional sources of funding for adaptive projects such as construction of surface-water treatment plants.

Innovative Community Adaptations

Dhaka has made greater progress in addressing environmental issues, specifically in community-based adaptations, than its meager financial and planning resources would otherwise suggest. On the one hand, Dhaka and other cities in Bangladesh are hindered in their implementation of adaptation measures because they lack both resources and institutional capacity, disadvantages compounded by the country's location in one of the world's most climatically vulnerable zones. On the other hand, particularly at the community levels, the nation has made greater strides in climate adaptation than have most other developing nations in the region and even globally. Bangladesh has used the knowledge and experience drawn from its recurring struggles with natural disasters and climate hazards to "do more with less".

A large part of this success has been due to the inherent resilience of Bangladeshi people where they have had to cope with recurring disasters such as cyclones and floods. For the more socio-economically vulnerable segments of the population, adaptation in some cases has been the only pathway to survival (Interviews 1, 3, 5, 8 and 9). In areas where civic infrastructure and aid is unavailable, many communities have also employed many innovative ways to autonomously adapt to changing circumstances. For example in the peri-urban areas of Dhaka, where saline intrusion has made rice farming more difficult, farmers have converted paddies to crab farms (Anik, Khan, and Sayed, 2012).

These community-based adaptations have in large part been successful and persisted because of the support of a number of national and international NGOs and development partners such as CARE, IUCN and UNDP. Moreover, the government of Bangladesh, through its Community Based Adaptation Programme, also has a number of articulated schemes to support community adaptation, particularly in the water and agriculture sector (Ahmad, n.d.).

An especially innovative example of community adaptation, which has been scaled up adopted in other communities around Bangladesh, can be seen in the case of "floating gardens".[39] Based on the principle of hydroponics, this technology finds a way to utilize flooded or water-logged land for food production which has been found suitable both for short-term disaster relief as well as building long-term resilience. For the most part, the floods of 2007 were a major catalyst for this work, which was first initiated in Gaibandha, Northern Bangladesh (Rahman, 2009).

Other examples of how existing resources have been utilized to create effective adaptation strategies include growing tailored crops in water-logged areas to create agricultural surpluses, thereby reducing climate-change-induced food shortages; diversifying livelihoods to decrease dependence on specific industries; stimulating grassroots action to increase awareness of the dangers of climate change; and developing successful government-directed irrigation schemes. In drought-prone regions of northwest Bangladesh, rainwater preservation, through the

[39] Built on a raft of water hyacinths (which are widely available in Bangladesh), the typical floating garden measures 8m by 1m. The vegetable seeds are planted inside the raft, which holds a "bed" composed of soil, compost, and manure. The life cycle of such a raft is about one year, after which, in the dry seasons, the raft itself distintegrates and is subsequently used as fertilizer. For the people of Gaibandha, these floating gardens provide subsistence, especially during periods of severe food shortage. In some cases the surplus vegetables are sold to augment incomes as well. Because of the mobility of the rafts, they can also be moved away from locations that experience flooding or saline intrusion. The training efforts for the program were tailored to local levels of expertise and integrated with broader climate-change educational measures.

establishment of a network of storage facilities, has augmented potato and wheat crop yields, provided employment for tenant farmers and agricultural laborers, and raised rural income levels. Each of these measures augments the population's resilience to the impacts of global climate change. The success of adaptation measures in greater Dhaka thus stems in large measure from the actions of a resilient, independent population engaging in autonomous adaptations that are often principally economically motivated.

Increased Perception of Climate Risks

Given its particularly vulnerable geographic situation, Bangladesh more clearly perceives the risks resulting from climate change, such as flooding and catastrophic weather events, than do most countries in this region. Davidson, Williamson, and Parkins, (2003) cite risk perception as a crucial motivator in risk assessment and argue that entities are much more likely to attempt to respond to hazards under such exigent circumstances; heightened risk perception prompts "actions that lead to adaptive strategies" (Parkins, 2008). In such situations, as in Bangladesh, the presumption that the threat is palpable greatly increases the likelihood that the nation will seriously address the issue of climate change. The perception of risk in Bangladesh was particularly acute during 2007, when Bangladesh experienced two disasters ---a category four cyclone, "Sidr", and consecutive monsoon floods that devastated the entire country. The cyclone itself claimed over 3000 lives, causing tremendous economic losses of about $1.7 billion as well. In the aftermath of this widespread climate-related damage, the efforts to address climate change were significantly intensified. The Bangladesh Climate Change Strategy and Action Plan (BCCSAP), for example, was formulated, providing more hands-on guidance to adapt to climate change. In addition, the Climate Change Trust Fund was also established during this time by the Bangladesh government as was the donor-funded Climate Resilience Fund (Alam et al. 2011).

Bangladesh's growing commitment to climate-change adaptation is thus partly the result of clearer perceptions of the nation's climate vulnerability. This clarity stems principally from the increasingly severe weather events that the nation has been experiencing. This awareness—coupled with rising political commitment, fresh approaches to organizational structures, and community-based autonomous adaptation actions—has made an appreciable difference in increasing Dhaka's adaptive capacity and thus reducing its climate risk.

THE BARRIERS TO ADAPTATION

To determine which climate-adaptation strategies hold the greatest promise for South Asian cities, I will first examine several unsuccessful efforts, in order to identify the policy, planning, institutional, resource, and implementation factors that hinder effective adaptation. The three cases described below—flood control in Kolkata, water supply in Kolkata, and wetlands preservation in Dhaka—provide a foundation for understanding the reasons why the case studies presented in the next chapter proved significantly more fruitful.

Flood control in Kolkata

Although Kolkata is considered one of the most flood-prone major cities of the world (WWF, 2009), the city lacks both specific structural measures for controlling riverine floods and explicit city-level policies or plans for flood prevention or management. Whatever flood-related measures exist are largely under the purview of the state level Department of Irrigation and Waterways (*www.wbiwd.gov.in/)*. As discussed earlier, Kolkata does have a rudimentary emergency disaster-management plan, which draws principally upon existing police, fire, and other emergency services during catastrophes, one that was somewhat augmented after the devastation of Cyclone Aila (May 23rd-26th, 2009). Although the city's overall vulnerability to flooding should be readily apparent, the general pattern among municipal planners and city officials of Kolkata, as revealed through field interviews, has been to maintain that such infrastructural adaptations "do not fall under their jurisdiction" and that it is the State department which generally handles flooding-related activities (Interviews 67, 68, 69, 72, 80, 86, 88, 89 and 90).

The majority of city planners (both at KMC and KMDA) have focused their efforts on increasing the sewer and drainage capacities of the city as part of "regular" developmental efforts, rather than on climate adaptation.

> Yes, of course we have departments that are in charge of the sewer and drainage facilities of the city, but those things are not for flood protection. Water, drainage and sewer infrastructure is required for any city that is developed . . .

(Senior Officer, KMC, Interview 67; translated by author).

Though such infrastructure projects do address flooding caused by water-logging due to overflow of storm water systems during periods of intense rains and storms, these additional benefits are merely "serendipitous" in nature, not planned adaptations undertaken to lessen climate risks:

> Maintenance of the drainage system of course helps with the water-logging; that is why we are in the process of cleaning them [the pipes] up. But we have to do it anyway, to make sure the drainage system works properly, but the main reason to do it is not to stop floods, but for general sanitation purposes
>
> *(Water Engineer, KMC, Interview 72; translated by author).*

Flood-control measures, such as construction of embankments and regulators, excavation of some drainage channels, and construction and maintenance of flood-pumping stations (in the Kolkata port area as well as in the surrounding peri-urban regions), are primarily planned and executed by the Irrigation and Waterways Department (IWD) of the State of West Bengal. This department also maintains both a repository for daily river- and rain-gauge data and the "Flood Warning System" for the state of West Bengal, including Kolkata. According the Department's most current report of activities for 2011-2012,[40] three specific items were directly related to flood protection, response to increased rainfall, mitigation of future cyclone damage, and "resuscitation of major drainage channels in Kolkata Metropolitan area". Moreover, the draft version of the *Climate Change Action Plan for West Bengal* delegates a larger share of responsibilities to IWD, in which the IWD is envisioned to play an even stronger role in the management of water resources and flood protection.

In one of the very first interviews that I conducted in Kolkata, with a very high-level planner and executive officer at the KMC, I was alarmed at the ignorance of climate change that the interviewee demonstrated:

> Climate change...yes. The climate is always changing...What can we do? It has now become hotter in Kolkata—before we used to sleep on the terrace in the summer but now there is so much pollution. Many years ago, the people of Kolkata used to go to

[40] Please visit http://www.wbiwd.gov.in/pdf/irrigation_synopsis.pdf for full report.

> Simla [is the capital of the State of Himachal Pradesh, a northern hill-station with cooler climates] to escape the summers [of Kolkata]. Now we don't do that anymore...everyone is too busy. Also Simla is not the Simla it used to be
>
> *(Senior Director, KMC, Kolkata, Interview 66; translated by author).*

This quote in a way echoes the general ignorance on the causes and impacts of climate change in Kolkata that was demonstrated by many of the officials that I interviewed at the KMC. More specifically, insights gleaned from the analysis of interviews (for example 66, 67, 69, 70, 71and 79), and field observations in Kolkata point to three key reasons for the absence of not only specific flood-control measures by the city agencies, but also other any other comprehensive adaptation planning that the city so urgently requires.

First, there is a general *lack of awareness* among city planners that riverine flooding simultaneously exacerbates urban flooding when storm-water drainage capacities are breached. Historically, Kolkata has experienced periodic riverine flooding, which has been managed by the State Department of Irrigation and Waterways, and relief efforts during severe flood situations have been directed by the national government. Therefore, riverine flooding is considered a normal and somewhat regular event in the city, one for which the city's agencies thus believe they need not take additional action (Interviews 67, 72 and 73). Moreover, urban flooding due to intense periods of precipitation has been a relatively recent phenomenon for the city; in interviews, officials attributed such inadequate storm water capacity to the rapid and unregulated urbanization of the city.

> Yes in the last 5 years we have had more rains in Kolkata than before, but nobody can predict exactly. Water-logging is not only happening because of rains. You have to understand that there is so much growth that Kolkata is facing, our population is increasing everyday with people from Bangladesh and Jharkand (a neighboring Indian state) coming in so fast. With all this [rapid growth], we have more slums and lots of illegal buildings now, which are going up because everybody takes bribes. It is very difficult to monitor these things [illegal development]. Of course our drainage system has been unable to keep up and we are trying to expand it. If we are able to have a good drainage system, then we don't have to worry about all this flooding [because of water logging]

(Senior Officer, Water and Sewer Department, KMC, Interview 67; translated by author).

In light of such growth, providing for the expanding population seems a more urgent task than does addressing climate risk.

Second, *resource constraints* (primarily technical and financial) play a pivotal role in the actions undertaken by city agencies. As discussed earlier, the Kolkata Metropolitan Corporation (the city's primary planning agency), in particular, lacks the necessary financial resources to plan for and implement new adaptation initiatives, unless the projects principally further development, as with augmentation of the drainage network. Even in such cases, these efforts have not been reconfigured in recent years to account for any additional climate risks (Interviews 67, 71, 72 and 73). The overextended budget of the extensively indebted agency (as discussed earlier in chapters 1 and this chapter) is utilized mainly for general development and maintenance, activities that have comprised a large part of its traditional responsibilities. This paucity of financial resources stems from two principal causes. First, the agency, like many other local administrative units, possesses no dedicated revenue base and experiences great difficulty in collecting and enforcing assessments. Second, the state of West Bengal, which was under communist rule for almost 35 years (1977-2011), has tended to have an overly centralized budget function, leaving few earmarks for local administration. Moreover, this centralization engenders competition and territoriality among state and local agencies, as naturally the portfolio of responsibilities determines agency budgets. Where city-level agencies, such as the Kolkata Environment Improvement Trust (KEIP) and certain project-based units of KMDA, have made significant strides outside their regular functions, they have usually been funded by loans from international donors or from the national government, as in the case of the JNNURM schemes.

Lack of technical capacity has also been a key hindering factor in taking on additional projects even when resources are potentially available. For example, according to a senior official at the KEIP, the Asian Development Bank approached the KMC in 2010 to provide a "soft loan" to plan and implement flood-control projects. Given the technical expertise needed to execute such projects and the stringent reporting and functioning criteria that the ADB—like other international agencies—requires, however, the KMC is yet to take the Bank up on its offer. ADB has also mandated that the KMC and KEIP raise funds through additional water taxes in order to receive the Bank's support (*The Statesman, 2006: 1).* Presently in Kolkata there is no formal taxation on water supply, which constitutes a very important prospective revenue base for the city, as discussed in further detail in the section on Water Management in the next chapter.

Third, *institutional ineffectiveness* and *unwillingness to take on political risk* play a significant role at both the state and local level. In most cases, these considerations determine not only the types of projects that are initiated and implemented, but also the level of post-construction maintenance. In the case of infrastructure projects that would address urban flooding of Kolkata, institutional inertia, blurry distinctions of responsibility and authority, and an unwillingness to take political risk pose strong barriers. For example, the IWD has traditionally held responsibility for the construction, reclamation, and maintenance of embankments, dams, regulators, pumping stations, and drainage canals related to flood water, for the State of West Bengal. In past years, a majority of this work took place in the rural areas of the State, where measures intended to adapt to intense rainfall and excessive flooding are underway.[40] With the altered climatic patterns and rapid development of Kolkata, the IWD has now built many additional pumping stations and reclaimed some of the existing canals in collaboration with various local agencies in Kolkata, including the KMDA and KMC (Interviews 67, 70, 71, 73, 79 and 80). The KMC, whose ostensible territorial authority has expanded to match the growth of the city, would normally possess authority for all such infrastructural maintenance and new construction within the city limits. However, interviews with key officials of IWD revealed that the local agency has proven unwilling to accept this responsibility, especially for infrastructural maintenance, citing that these duties have traditionally been carried out by (and funded through) State-level agencies.

> You cannot get those people [KMC staff] to do anything. We have been trying to hand over the charge of the pumping stations in Kolkata to the KMC for almost five years now. Even our minister called the mayor for this. But they always say that they do not have the manpower to take this extra charge, though that was decided at the high level. They are now saying that their engineers are not trained in maintaining the pumping stations properly and we have more qualified people on staff. I just think it is because they don't want to hear more complaints from the people of Kolkata every time we have water-logging. As you must have seen, even the press is after them now

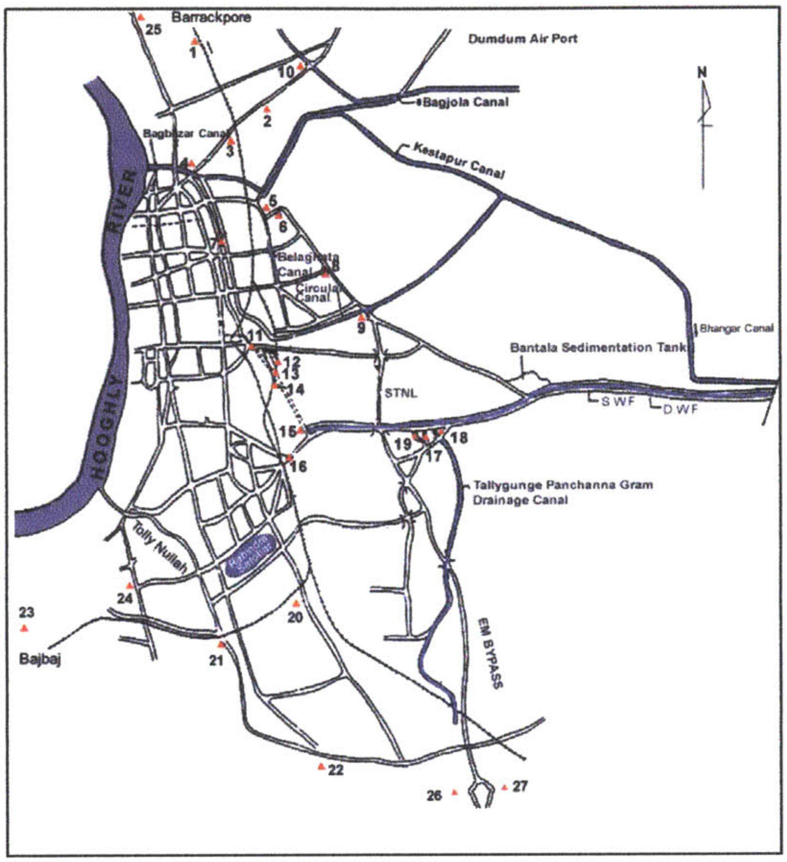
(Senior Official, Irrigation and Waterways State Department, West Bengal, Interview 63; translated by author).

The demarcation of control of the components of the Kolkata drainage system (Figure 3) serves as an illustrative example of the irrational and inefficient patchwork of authority and ownership. The IWD, the KMC, the KMDA, West Bengal's Public Health Engineering Department, and the Calcutta Metropolitan Water And Sanitation Authority, CMWSA, each manages one or more of the city's 27 pumping stations.[41] This disjointed system of ownership necessarily creates a lack of overall accountability, eliminates economies of scale in the utilization of financial and technical resources, and leads to piecemeal maintenance. Perhaps most important, under this fragmented approach, the drainage system cannot be assessed or planned for as a comprehensive unit, thereby limiting the system's overall effectiveness.[42]

[41] The IWD manages pumping stations 17, 18, 19, 22, 26, and 27; the KMC holds responsibility for stations 1, 3, 4, 5, 6, 7, 8, 9, 11, 12, 14, 15, 16, and 20-23; KDMA controls station 25; the State's Public Health Engineering Department maintains stations 2, 3, and 10; and the CMWSA runs station 13.

[42] The fragmented institutional makeup can be considered a historical artifact, one attributed to the progressive patterns of Kolkata's development across more than a century, with particular areas built at different times to serve varying populations. Kolkata's essential infrastructure was entrusted to the IWD during the period of communist (highly centralized) rule, a situation that began changing, albeit slowly, in 2012, when the administration of KMC was taken over by an elected Mayor, who belongs to the new majority ruling party of West Bengal.

FIGURE 4.1: Map of Kolkata Drainage System
Source: http://wbiwd.gov.in/flood_mgmt/maps/pumping.htm



Locations of Different pumping Station
For Kolkata Drainage System

LEGEND

Pumping Station ----------
River ----------
Cannel ----------

No.	Name
1	Birpara Pumping Station
2	Laketown Pumping Station
3	Dutta Bagan Pumping Station
4	Belgachia Pumping Station
5	Ultadanga Pumping Station (Old)
6	Ultadanga Pumping Station (New)
7	Maniktalla Pump Station
8	Maniktalla Pumping Station
9	Dhapa Lock Pumping Station
10	Kashipur Draig Pump
11	Palmer Bazar Pumping Station
12	Pagladanga Pumping Station
13	Chingrighata Pumping Station
14	Kulia Tangri Pump Station
15	Topsia Pumping Station
16	Ballygunge Pump Station
17	Chowbhaga Old Pump Station
18	Additional Chowbhaga Pump Station
19	2nd Additional Chowbhaga Pump Station
20	Jodhpur Park Pump Station
21	Chetla Lock Pumping Station
22	Keorapukur Pumping Station
23	Nimak Mahal Pumping Station
24	Mominpur Pumping Station
25	Baranagar Noapara Pumping Station
26	Uttarbhag Pumping station
27	Addl. Uttarbhag Pumping station

Lastly, *lack of political will* for initiating much needed flood infrastructure projects that can adapt to the increased urban flooding in the city also plays a principal role, as widely confirmed by many state and local officials.

> We can only get things done if the political parties make it a priority like they have in the case of what KEIP is doing. That is also because there is a lot of money coming in from ADB, which is why everyone is interested. Our new chief minister is very concerned with the beautification of the city…we have been ordered to paint all the government buildings three times in one year. Mostly the state government is responsible for flood protection; we have not been

> officially asked to do anything in that category yet. We are currently charged with improving the water supply and sanitation in different parts of the city for which we have a master plan, which was completed in the 1960s. We are updating it now
>
> *(Officer, KMC, Interview 70; translated by author).*

The political risks associated with spearheading climate-adaptation projects greatly outweigh the "perceived uncertain benefits" accruing from such measures, especially if the embankments or pumping stations prove unable to control severe flooding, leading to even greater scrutiny of city officials by the city's residents.

Water Supply in Kolkata

Kolkata, faces some of the same challenges in water supply as does Dhaka, but with a few significant differences. First, Kolkata's water crisis is currently less severe than that of Dhaka, because the city does have a steady source of somewhat less-polluted surface water from the River Hooghly. Despite the relative abundance of surface water to meet the needs of the city, however, a substantial portion of Kolkata's water supply comes from groundwater because of poor management and distribution.[43] According to the KMCs *Ground Water Information Booklet*, published in 2007, between 1986 and 2006 the number (likely significantly underreported) of "official" deep and shallow tube-wells fitted by KMC has increased from 232-264 to 5000-10,000, respectively. Moreover, even according to conservative estimates by KMC, the extraction of groundwater lowered the groundwater table by between seven and eleven meters from1958 to 2003, considerably worsening the city's supply situation.

Apart from availability, water quality is also a pressing issue in both cities; whereas Dhaka must deal primarily with the looming threat of salinity

[43] Some areas of Kolkata, particularly the affluent neighborhoods of its southern part, receive piped water supply for over twenty hours per day, primarily from the Garden Reach Water Treatment and Distribution Plant, while others do not even receive water for three hours daily (Ghoshal, 2009). Although the KMC manages a majority of Kolkata's water supply, the Kolkata Metropolitan Water and Sewer Authority (KMWSA) handles some aspects of the city's water supply, including the operation and maintenance of one of its major water plants.

intrusion,[44] Kolkata has to contend with the hardness and arsenic contamination of its water supply, which is becoming increasingly hazardous as groundwater extraction intensifies (Mukherjee et al., 2006).

> We are never sure how dangerous our drinking water is—how much arsenic it has. I am not a scientist, so I am not able to test this. To be safe, we all [people of Kolkata] boil the water before drinking even though the Water Supply Authorities [KMC] say that it is safe to drink tap water. My work is to save the ponds and wetlands in Kolkata; someone else has to revolt against the quality of water supply in this city before it is too late.
>
> *(Mohit Roy[45], Environmental Activist, Kolkata, Interview 96; translated by author).*

The present circumstances demonstrate that adaptation-related components are fundamentally absent in the water management of Kolkata. The several ongoing projects for improvement and augmentation of water and sewer infrastructure (mostly via the KEIP) serve almost exclusively as development measures for regular expansion and provision of urban services rather than as adaptive efforts.[46] Alarmingly, the city has neither specific water policies, nor a comprehensive resource management plan, to guide the development of its water sector.

Water Management

KMC's Water Department manages the water supply for most of Kolkata, overseeing an area of 185 km^2, corresponding roughly to the boundaries

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[44] Rural Bangladesh, in which residents rely almost entirely on groundwater for drinking, does experience life-threatening levels of arsenic contamination, of up to 3200mcg/l (versus a WHO safety standard of 10mcg/l and a national standard of 50mcg/l). Dhaka itself, however, is less at risk (British Geological Survey, 2001).

[45] Mohit Roy is an environmental activist and engineer who is actively involved in documenting the conditions and creating awareness of Kolkata's ponds to further conservation efforts. He authored *Old Mirrors: Traditional Ponds of Kolkata*, which archives existing and extinct ponds of Kolkata, to further preservation efforts.

[46] The city currently has four water-treatment plants, three managed by KMC and the other by KMWSA. Two other plants are planned: one will have a 30 MGD capacity and the other will augment the capacity of the Garden Reach Waterworks Treatment Plant by 15MGD. Apart from the treatment plants, five new pumping stations with reservoirs have been approved. In addition the KMC is also now replacing/repairing its 5000-km existing pipe network and improving its grievance addressal system to a digital interface.

of the city proper. As of 2007, KMC city officials estimated the water demand for the city at 290 million gallons/day (mgd).[47] The agency claimed that it was able to supply about 300 mgd on average, giving about 94% of the city access to piped water supply.[48] In the face of little improvement of water infrastructure and services in the last ten years, these projections seem remarkably optimistic, given that independent assessments of service indicators for water supply from only a decade ago (through 1997) tell a different story, one which presents a grave scenario for water security for the city (Chennai Institute of Development Studies [MIDS], 1995; ADB, 1997). Coverage areas for Kolkata increased by a mere 2%, from 64 to 66%, during this time, while average water availability remained at 10 hours/day.

Several key factors contribute to this lack of any concerted water policy and gradual degradation of supply. One of the key detrimental forces is the high level of political involvement in day-to-day affairs of the city's agencies. Though the KMC, and in some cases the KMWSA, do have responsibility for collecting water taxes and maintaining infrastructural assets, they are nevertheless subject to political interference, insofar as both agencies depend directly or indirectly on the State or central government for financing. These circumstances impact the functioning of these agencies, because they have no financial or functional autonomy to plan for efficient operations. An interview with a KMC official in May 2012 revealed a startling situation that exemplifies this difficulty. A new water supply line, which had been approved to service a certain area, was then rerouted—at substantial additional cost—through another neighborhood at the behest of the local Member of the Legislative Assembly (MLA). This not only added to the overall expense and duration of the project, but also resulted in a lower level of water supply than had been originally intended. In fact, the agency seems to be oriented more towards meeting political commitments than towards servicing the citizens or developing any comprehensive water-management policy for the city.

One of the most compelling problems in regard to revenue generation and

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[47] The KMC's own report to the ADB, in applying for funding for additional water infrastructure needs, concedes that its current level of water supply is seriously inadequate for the city's needs, however (KMC, 2012).

[48] Ghoshal, 2009. The KMC website does not provide any specific information regarding the current water demand of the city or its current supplies. Field interviews with KMC officials in May 2012 also did not supply any additional data.

a resulting degree of financial autonomy stems from the fact that Kolkata city charges no direct fees for access to water. Though "free" water—with revenue for water infrastructure and provision coming from property taxes—was the norm in some Indian cities, such as Mumbai and Chennai, this approach has not worked well in Kolkata. A primary reason for this failure is that property tax collections in Kolkata are significantly lower than those in many other major Indian cities, including Bangalore, Mumbai, and Pune. Collections in Kolkata run consistently at less than 40% of tax demanded as well (Mathur, Thakur, and Rajadhyaksha, 2009: 17). Although the imposition of a water tax[49] would naturally face opposition, the strategy employed thus far, on a limited basis, has been to begin metering in government and private housing complexes. Since the residents of such areas enjoy well-above-average incomes, and since metering will enable a more consistent supply, opposition has been relatively mild (Ray, 2012).

In addition to its problems in collecting water revenue, KMC faces severe difficulties in property tax collection as well. Because of mismanagement by the KMC, property assessments in Kolkata have not been revised for more than two decades, resulting in grossly insufficient tax revenues, especially since property values have been growing at a rate of 7-19% annually (ICICI Property Services, 2012). Little funding for water-related projects is thus available to the KMC and related agencies (Guha, Thakur, Konar, Biswas, 2011; Ruet, Saravanan, Marie, Zrah, 2010).

In addition, given that most water connections in Kolkata lack the equipment necessary to measure outflow (and very few metered connections have been established), it is in practice impossible for city officials to monitor—or even reliably estimate—water supply, usage, or level of wastage. To rectify this situation and generate sufficient revenue to maintain and upgrade its water services, Kolkata must establish metered connections throughout the city. With both the clear need to implement such changes and significant external support and pressure for doing so, Kolkata still mostly lacks water meters. In 2007, for example, KMC (through KEIP) received a $113.6 million loan from the ADB for improvements in the water sector; establishing metered connections was one of the primary loan conditions. However, since paying for water is a highly politicized item and closely linked with political popularity, the

[49] Perhaps the major impetus for water metering and taxation is pressure from external funders. Both JNNURM and the ADB have made water metering a condition for future funding (Ray, 2012).

project was stalled by city officials until the end of 2012. More recently, KMC lost a significant portion of its external funding from JNNURM (25 crore rupees, or about $5M) for its politically engendered failure to implement mandated revenue reforms, including metering (Ray, 2013). The recent efforts to increase its revenue base have thus far proven insufficient to support the KMC's water-supply efforts.

In addition to this political interference, deficient organizational structures have limited the effectiveness of many agencies in Kolkata. Specifically, several shortcomings—incomplete political decentralization, bureaucratic hierarchies (which engender tension between state and local agencies), compartmentalized decision-making and unclear lines of authority among local agencies themselves—lead to financial mismanagement and confused planning processes. Analysis of the KMC and KMWSA, for example, reveals substantial overlaps and gaps between the duties of the two local agencies, which hold joint responsibility for managing the city's water supply, much like the redundancies in planning authority between KMC and KDMA. The resulting divided authority further complicates accountability, perpetuates political deadlock, and sustains an inadequate *status quo*. KMC has experienced success in managing its operations only when subject to external oversight, usually from the ADB.

Third, KMC's unwillingness or inability to modernize its processes and planning over the years is also a key contributing factor. The agency's operations are moreover often characterized by rent-seeking behavior on the part of many of its officials[50], providing additional incentive for bureaucratic inaction and delay. Since there are few mechanisms to hold KMC—or the city's other agencies—financially or administratively accountable for performance, KMC is under little pressure to innovate or even run efficiently. Though the KMC's senior officials—including the city's mayor, nominally the head of KMC—are elected representatives, by and large, most employees at KMC have nearly inviolable job security[51]. The

[50] From handing out rich contracts without legally mandated bidding to defrauding thousands of residents through assessment scams, KMC has experienced more or less constant corruption scandals (Ray, 2010).

[51] KMC is gradually making some headway in trying to improve its performance. On February 29th, 2012, in a significant move in the history of the agency, one of the most corrupt senior-level officials was transferred from his key position as Director General of the Buildings Department, after a complaint to the Chief Minister by other senior-level officials (*The Statesman*, 2012b).

ensuing difficulties—the highly bureaucratic nature of the organization, its improperly articulated functions, and its lack of institutional capacity—have not only degraded the city's current water supply, but also hampered its future water management policy. [52] An illustrative example comes from an interview with a project director at KMC, who identified yet another serious deficiency in the agency's performance. He explained that KMC has been unable to maintain or upgrade large segments of the city's already-aging water supply pipe networks because no extant schematics or renderings specify the exact locations of the networks. Since the establishment of the first waterworks in Kolkata in 1909, very few detailed records have been kept or drawings made on the subsequent modifications and additions. Given that most of the engineers of KMC who had been responsible for the changes to the original system are now deceased or retired, the agency is finding it difficult to conduct regular maintenance and carry out new projects, as it simply does not know where its pipes are!

> We [the KMC Water Department] were supposed to repair a major leak in a branch water supply pipe in South Kolkata last month and needed the drawings to know the exact locations in order to excavate. Since these lines were laid well before the time of our [currently employed] engineers, we were not able to find the drawings for this particular section. Someone suggested that we meet with the previous engineer who had retired since then. I personally went to his house, but found out that he had passed away a few years before. Finally, we had to dig up a very large segment just to find the leaking pipes, which would have been unnecessary had we had the drawings. Then the whole thing became so costly and we had to face so many delays and protests

[52] The lack of managerial and financial capacity stems from a number of causes. Much of the agency's dire financial situation results primarily from KMC's inability to collect its revenues, for which the severely inadequate personnel allocation is responsible to a large degree. Currently, there are no assessor collectors in any of the boroughs to even initiate revenue collection or determine dues. Of the 1400 employees on the KMC roster, about 1250 are technical personnel mostly concerned with engineering functions. In effect, there are only about 30 managers who are responsible for the administration of the entire KMC territory. As a result, a single manager is in charge of over 30 wards simultaneously; much of each manager's time is thus spent on day-to-day administration. Consequently, revenue collection lags far behind. Moreover, with the "promotion" of the engineers to senior levels, their job responsibilities are reduced significantly with no additional hires made to fill the gap (*The Statesman*, 2012).

> [from the people of the neighborhood]. In the end, though we got the job done, we had to face so much criticism despite this not being our [the current employees'] fault
>
> *(Water Engineer, KMC, Interview 73; translated by author).*

Three principal issues—political pressure, ineffective management structures, and outdated processes—thus combine to severely limit the effectiveness of the KMC. Though similar issues plague other organizations in both Kolkata and Dhaka, it is in the KMC where these problems have proven most debilitating. Thus, in order to pursue effective climate adaptation in Kolkata, these issues involving KMC must first be addressed. My research suggests that the Kolkata Environmental Improvement Project (KEIP) might provide certain answers.

Though technically under the auspices of the KMC, KEIP has generally functioned rather independently of KMC control, with greater direct accountability to its external funding sources, primarily the ADB and JNNURM. When the two agencies have carried out similar measures, such as installing new sewerage and storm drains and water-supply lines, the KMC-led projects have been far less successful. KEIP has utilized its *strong external relationships* to limit politicization of its efforts. The Project has moreover been able secure targeted external funding for high-value projects through its *corporate methods*. Additionally, *innovation* in the use of technology and outside expertise has greatly enhanced efficiency. The example of KEIP, explored further in the next chapter, shows that the situation of Kolkata's water supply is bleak, but not hopeless.

Wetland Management in Dhaka

Lost Opportunities for Low-Cost Adaptation: Dhaka's Disappearing Wetlands

Unlike Kolkata, which has experienced considerable success in managing and preserving the East Kolkata Wetlands, Dhaka has lost much of its once-extensive wetlands areas over the past fifty years.[53] According to a

[53] Although Bangladesh signed the Ramsar Treaty in 1992 (India had joined a decade earlier), the rate of wetlands loss has not significantly abated since (Ramsar.org, 2013).

study conducted by Reza and Alam (2002), the permanent wetlands, which had covered about 22% of the 146 km^2 of western Dhaka in 1968, declined to 13% in 2000. The loss of the temporary wetlands (floodplains, depressed areas, and marshes) was even more significant; the city lost 43.67% of its temporary wetlands over the same period (Reza and Alam, 2002). Within the 256 km^2 of Dhaka city proper, an estimated loss of 10.1% in open water bodies was also recorded between 1968 and 2001 (Sultana 2005). A more ambitious study by Hossain et al. (2005), which covered an area of 800 km^2, in and around Dhaka, found that around 268 km^2 of wetlands had been permanently lost just between 1990 and 2000. Perhaps the most alarming and definitive projections of this irreversible and damaging trend comes from the findings of a comprehensive and more recent study by Islam (2009), which projects that the urban wetlands within Dhaka city will be completely lost by 2035. Islam's conclusions are extrapolated from a measured annual loss of 8.37 hectares/year from 1999 to 2005, a 35% increase from the prior decade, during which the rate was estimated at 6.2 hectares/year.

When we consider the impact of this destruction on the city's drainage, where until the past decade, the municipal drainage system serviced only about 25% of Dhaka (SWMC 2002), the loss of urban wetlands has severe implications, particularly in the city's ability to adapt to water-related climate and extreme weather impacts. In terms of internal flooding (or water-logging) alone, the wetlands have historically been a crucial component of the city's drainage system; the *khals* (or natural drainage channels) have diverted excess water away from the more developed highlands to low-lying undeveloped areas or peripheral water bodies. According to Chowdhury et al, 2001, Dhaka had forty-three major khals, which had served as crucial drainage channels until the late 1990s, conveying both wastewater (domestic and sewerage) and stormwater runoff to surrounding rivers. These khals have gradually been filled up, or become unusable, because development activities have changed Dhaka's natural drainage patterns.

In addition to reducing water-logging and functioning as a crucial component of the city's overall drainage system, there are more readily palpable and cost-effective adaptive benefits of preserving the wetlands. These major factors associated with preserving Dhaka's wetlands are clear not only to the research community, but city officials as well.[54] Three

[54] Responses from the interviews with senior officials of RAJUK, planners at the DCC, and engineers at DWASA indicate strong awareness of the various implications of the

such factors surfaced repeatedly in my field interviews: flooding, groundwater recharge, and biodiversity.

> When Dhaka city was founded, despite the flooding from the rivers, we knew that Mother Earth had also given us the wetlands, which would absorb all the floodwater. We also used to have a lot of fish-farming in the city because of the ponds, but now all that has gone, and so many poor people are without livelihood. The developers build wherever they want and all these new buildings in Dhaka that you see mean that you don't see the wetlands any more
>
> *(Senior Employee, Dhaka City Corporation, Interview 35; translated by author).*

First, the destruction of Dhaka's wetlands directly affects the flooding situation of the city. Inside the city's embankments, the floodplain wetlands serve as stormwater retention areas, and outside the embankments the wetlands absorb overflow from adjacent rivers. The effects of filling wetlands on the surrounding hydrology include increased water level and flow velocity of surrounding rivers, both of which further exacerbate the drainage problems of the city (SWMC 2002).

Second, since the lowlands (part of the wetlands) are instrumental in recharging groundwater, the loss of wetlands directly reduces the groundwater recharge area and thereby lowers the city's water table. A 2000 study by the Surface Water Modeling Center, Bangladesh (SWMC) found that just between 1995 and 1999 the annual decline in the water table of Dhaka city ranged from 1.02 to 2.46 meters. Given that 87% of Dhaka's water supply comes from groundwater, the loss of wetlands has severe implications for the city's water supply.

Third, the destruction of wetlands has dramatically impaired the local ecology and diminished the biodiversity of the area. During the dry season, the wetlands in and around Dhaka had high agricultural value; the fertile flood plains of the Brahmaputra delta have traditionally provided substantial yields of rice and other semi-aquatic crops. During the wet season, these wetlands naturally merged with the surrounding rivers and functioned as fishing areas. This seasonal combination of agriculture and aquaculture afforded year-round economic subsistence to millions of Bangladeshis, but the filling in of the wetlands has progressively degraded the area's food production. These wetlands moreover maintain the ecological cycles of the region, as do those in East Kolkata.

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loss of wetlands of Dhaka City, particularly as it relates to the water sector.

Reasons for Loss of Wetlands in Dhaka

Despite the broad awareness of the critical repercussions arising from the increasing loss of urban wetlands, neither city officials nor political authorities have yet made serious efforts to rectify the situation. Two primary elements contribute significantly to this predicament: social and economic pressures arising from population growth; and institutional factors exacerbated by resource limitations. The following analysis draws upon interviews with officials, primarily in RAJUK and DCC, with corroboratory evidence from recent studies (Islam 2009; Islam et al., 2005; Roy 2007; Haque 2004; Rafiq, 2012; Das, 2010), which have found similar evidence of illegal wetland development and encroachment.

Social and Economic Forces

One of the major reasons for the loss of wetlands in Dhaka has been the increase in demand for housing, fuelled in recent years by the rapid population growth, caused principally by rural in-migration. The resulting increased demand for housing and subsequent explosion in prices for improved land, which rose 7000-12000% between 1983 and 2005 (Islam et al, 2007), has created a lucrative economic opportunity for private land development companies (PLDCs). By 2006, 143 registered private real estate companies were operating in Dhaka alone; in the early 1980s there had been only five such companies (Roy, 2007). Other studies have estimated the actual number of such enterprises at 450, when accounting for the proliferation of unregistered (and thus illegal) PLDCs in the city (Rafiq, 2012)

With the exponential increase in land prices and relentless demand for additional housing, land-grabbing and exploitation of local wetland owners by the PLDCs has become not only relatively common, but also surprisingly easy, particularly since the land market was already endangered by "limited supply, sub-optimal use, poor tenure system, outdated land recording and taxation process while operating within a weak and ineffective administrative and legal framework" (World Bank and Bangladesh Center for Advanced Studies, 1999). Within this dynamic real estate market, several factors work in concert to make the wetlands very profitable for development. Unlike Kolkata, where the wetlands are at the boundaries of the city, Dhaka is interspersed with large tracts of wetlands in close proximity to the city center. The resulting access to the city infrastructure and transportation, coupled with prices that are considerably lower than those for improved parcels, makes these areas rather attractive for the PLDCs.[55] In a situation where legally developed land is among the costliest in the world, the less expensive, unimproved wetlands are drawing significant investment attention. This presents an opportunity for developers to get a quick return on investment, or ROI. The PLDCs can quickly and profitably develop and sell these lowland lots to buyers who would otherwise have not been able to afford housing in the city. Apart from the low rates for acquisition of land, the wetlands in and around Dhaka are available in large tracts, as they had been previously utilized for agriculture and aquaculture, rather than housing. Developers prefer larger tracts, as they enable economies of scale for the extensive landfilling necessary to undertake large residential, industrial, or commercial projects.

Another important reason that the wetlands have become the areas of choice for development is that the weaker social position of the typical wetland owner—a smallholding farmer—makes land acquisition easier. Most of these farmers are uneducated and rarely understand either the larger importance of the wetlands or the true value of their titles. When faced with the prospect of, what is to these farmers, lucrative and immediate compensation for their land, they can be easily motivated. For those who are unwilling to do so, as their land is their only means of subsistence and survival, the developers have often resorted to a number of exploitative practices to acquire the properties. National media have recognized that "the process of transfer of ownership of wetlands from the local farmers to the private developers is a story of aggression and exploitation," yet such transfers continue unabated (*The New Nation,* 2011). In some cases the PLDCs simply "grab" the land from the rightful owners or the government by falsifying documents. In other cases the PLDCs have bought out smaller parcels of land around the contested properties while filling in the surrounding parcels with sand to render plots unusable for agriculture. The PLDCs thereby eventually force the

[55] Various development projects, including embankments and roads, also naturally serve to increase land values and therefore to encourage conversion of wetlands to improved areas. In the case of Dhaka, for example, construction of the western embankment expedited development in western Dhaka. Similarly, the proposed eastern embankment has accelerated land purchases in the area by Dhaka's PLDCs. Several road projects, including the Dhaka-Ashuliya and Dhaka-Maoya roads, have made the wetlands more accessible for development as well (Islam, 2009: 92).

landowners, who have consequently lost their livelihoods, to sell out at below-market prices. As of 2006, thirty-six major real estate projects were identified in officially designated flood-flow zones, and seventeen other housing projects were in full operation in various sub-flood-flow zones of Dhaka; all of this construction contravenes existing local, state, and federal laws and regulations (Roy, 2006: 89). Overall, then, the built-up portions of Dhaka have increased in this fashion by 274% since 1975, as "Landscape diversity declined, urban dominance amplified, and the overall landscape mosaics became more continuous, homogenous and clumped" (Dewan, Yamaguchi, and Rahman, 2012).

Institutional Factors

A series of interrelated institutional shortcomings poses significant hurdles to addressing the issue of wetland management of Dhaka city. Perhaps the most significant of these are corruption and absence of political will,[56] hindrances that are endemic in the relevant agencies. Such failings are naturally rife throughout governmental organizations not only in Dhaka, but also throughout the Global South.

My interviews with officials and consultants of several local agencies, and members of the DOE and BWDB, revealed that the existing plans,

[56] A telling example of the power of political will can be found in the Dhanmondi area of Dhaka city. Dhanmondi, which is a very affluent neighborhood, was also once the site of a major dumping ground for residential waste. To build the landfill, much of the area's major khal (natural canal) and surrounding wetlands had been filled over. Just over a decade ago, the lake held dangerous levels of lead, as a result of landfill leaching (Ahsanuzzaman and Badruzzaman, 1998). As part of a strong political directive from Prime Minister Sheikh Hasina, the wetland area has since been recovered and preserved and is now managed effectively by the city. The wetland area within the neighborhood is now the site of a major urban park and focal recreational facility for the city. Though the reclamation of Dhanmondi lake and wetlands have been touted as an example of effective adaptation to climate-related water risks, its success had very little to do with its environmental benefits. The primary determinant of the project's positive outcomes was unwavering political support from the central government, in no small part because of the political influence of the area's wealthy residents. City officials even justified the project on grounds of historical significance rather than of environmental benefit: the wetland was adjacent to the former home and assassination site of Sheikh Mujibur Rahman, the founder of Bangladesh and father of Sheikh Hasina. The project was completed in a record time of three years (between 2002-05) at the cost of 10 lakh taka (~$172,000 at the time). However, the reclamation of the Dhanmondi wetlands has been merely a one-off effort and provides a demonstrative example principally regarding the effectiveness of political will in such contexts.

policies, laws, and mechanisms of taxation that pertain to wetland preservation and management are generally adequate. Without exception, the interviewees strongly maintained that the inadequate *implementation and enforcement* of current governance, rather than policy and planning shortcomings, are largely to blame for the failure to protect Dhaka's wetlands.

> We have the laws, but not the enforcement. So long as the government is corrupt and the people are greedy and want things instantly, it is impossible for things to change
>
> (Senior employee, Bangladesh Water Development Board, Interview 21; translated by author).

The respondents thus agreed that the existing policies and regulations—if properly administered and implemented—could suffice to achieve many planning and adaptation goals. These views reflect the substantial gap between project planning and what was actually happening on the ground. For example, the Dhaka Metropolitan Development Plan (DMDP) 1995-2015, prepared by RAJUK, clearly demarcates the Flood Flow and Sub-flood Flow zones, including their individual development restrictions, and specifies the locations of flood-retention ponds. The Detailed Area Plans based on the DMDP have yet to be completed, however, six years past the deadline; this failing has created several implementation loopholes, which the PLDCs have exploited. Lack of qualified staff and the corrupt practices of several RAJUK officials[57] appear to explain this inaction. Nevertheless, the Bangladesh Environment Conservation Act (1995), which addresses wetlands in particular (Farooque and Hasan, 1996), safeguards environmentally sensitive areas when they are demarcated in city master plans; the DMDP clearly falls within the purview of this Act. Despite such explicit environmental legislation, poor regulatory enforcement and the failure to implement existing plans continue to hinder adaptation efforts.

Apart from the implicitly (and explicitly) corrupt practices that enable wetland encroachment and lack of political will, several other factors also contribute to the indifferent attitude toward the preservation of Dhaka's wetlands. For one, five public agencies (RAJUK, RHD, DWASA, BWDB,

[57] In his research for Transparency International Bangladesh, Mahmud (2007) offers a very specific breakdown of corruption within RAJUK, largely responsible for building and land-use permits in Dhaka.

and DOE) across local and national territories share responsibility for the conservation of Dhaka's wetlands. This atomized management structure creates a fragmented operational approach that reduces transparency and discourages public participation in the process. This division of project oversight creates a blurring of actual responsibilities and lack of accountability (World Bank Sustainable Development Unit, 2007). Moreover, though it ostensibly bears general local authority, RAJUK, like other local agencies, possesses little autonomy in implementing or enforcing the existing plans and policies. Dhaka's agencies also lack the ability to coordinate necessary actions among different organizations and stakeholders. Wetland management thus involves minimal local input from institutions or the public.[58]

Moreover, the budgets of the local agencies do not allow for enough skilled, full-time, motivated staff to ensure proper enforcement or implementation of plans. These shortages also contribute to the failure to create effective Detailed Area Plans (DAPs) based on the DMDP, as discussed earlier.[59] In theory, local agencies do enjoy a viable tax structure, consisting of municipal, land development, wealth, income, and capital gains taxes; again, however, deficient regulatory enforcement, lack of political will, and systemic corruption serve to limit revenue collection (World Bank Sustainable Development Unit, 2007).

Comparative analysis of the approaches to wetlands management in Kolkata and Dhaka points to certain clear differences between the two cases. Key areas of contrast include the overall planning strategies used, methods of overcoming resource limitations (financial, technical and personnel), institutional organization, and levels of inter-agency coordination. The conservation of the East Kolkata Wetlands has proven more successful than that of Dhaka's wetlands primarily because of the approaches utilized by KEIP: institutional restructuring and allocation of dedicated financial and human resources; project management and coordination units; institutional innovation; and collaborative consultation.

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[58] Moreover, the major PLDCs are so powerful that they not only control grassroots activity but also exert strong influence at the center, by bribing politicians. In the case of wetlands management, where the nature of planning privileges centralized authority, such influence of the PLDCs at the national level is another bar to any substantial reform.

[59] The DMDP Project, which encompasses 1528 km^2 of the Dhaka Metro Area, was financed by the UNDP, and partially executed by the UNCHS and then handed over jointly to the Ministry of Housing and Public Works and RAJUK for further administration.

Although KEIP has also had its fair share of delays, cost overruns, and incomplete implementations, its results on the whole have been far more positive that those of similar undertakings in Dhaka (by RAJUK and other agencies). My research suggests that institutional barriers, especially unclear demarcations of responsibility among agencies and corruption, shoulder most of the blame for the disappearance of Dhaka's wetlands.

CONCLUSIONS

The state of adaptation in the two cities investigated in this research, Kolkata and Dhaka, is thus unpromising and likely to worsen. The most pressing concerns shared by the two cities—flooding and water-logging—have been exacerbated by a range of impeding factors, from unchecked development caused by population growth to inadequate funding, from corruption to lack of awareness. One principal factor, however, that seems to recur most often is that of institutional ineffectiveness, especially under conditions of multi-level governance (Daniell et al., 2011). While insufficient technical knowledge and resources are consistently problematic conditions, an overriding concern that emerged from the interviews is that of the vague, overlapping delegation of authority and responsibility. Where successes have come, clear chains of command and accountability are always present. The primary recommendations of the World Bank Sustainable Development Unit for Dhaka (2007), to focus on "implementing institutional mapping, reform and capacity building of key agencies", are borne out by the reality of climate-change adaptation in Kolkata and Dhaka.

5

MAINSTREAMING ADAPTATION IN THE WATER SECTOR: LESSONS FROM SOUTH ASIAN MEGA-CITIES

"What if we build a barrier and the surge goes beyond that?"

--Stephen Cassell, the cofounder of New York's Architectural Research Office

INTRODUCTION

Among the numerous interrelated impacts, climate change is expected to have on urban areas, the most critical will likely be experienced in the water sector. The altered hydrological cycle caused by climate change represents a significant climate stressor, insofar as this cycle affects several facets of human survival simultaneously, with dangerous impacts on other important sectors such as energy and biodiversity as well. The challenge of adapting to this climatically altered situation assumes an even greater importance in rapidly growing, yet resource-constrained mega-cities, especially in the developing world. Not only are natural climatic events, such as rainfall and tidal flooding magnified by climate change, but changes in water availability and quality (through risks such as groundwater depletion and salinity intrusion) will also have far-reaching adverse impacts on public health, economic stability, and food security.

These challenges are particularly evident in the already-vulnerable and expanding populations of many South Asian mega-cities. The two cities on which this dissertation focuses, Kolkata and Dhaka, both face significant impacts on water supplies. More broadly, likely climate-related impacts in these two cities can be classified into two groups: extreme *climate events*, such as urban flooding, cyclones and storm surges, and *climate sensitivities*, which are likely to effect the supply and quality of water more slowly and indirectly by threatening public health.

In addressing these *events* and *sensitivities*, a wide range of adaptation options is feasible in Dhaka and Kolkata but as with other planning processes, the actual choice depends on a wide range of non-climatic considerations (Huq and Alam, 2003; Nasra, et. al., 2010). For example, the types of development strategies, institutional dynamics as well as economic, social, and environmental factors, will shape the demand for and availability of water as well as the choice of adaptation options.

Planning for and managing water infrastructure are not only critical to development, but also provide significant opportunities to increase the adaptive capacities of resource-constrained cities without the need to allocate additional, climate-specific funds. Moreover, since water infrastructure can remain viable for over a century, such investments offer significant long-term adaptive benefits (Muller, 2007). In the context of Kolkata and Dhaka, there are many adaptation measures that can alleviate or avert climate-related deaths while conserving resources in the long run. Water-management and wetland-conservation approaches are less costly requiring low technology options while offering synergistic benefits.

From a policy and practice perspective, the notion that adaptation-specific activities cannot be separated from "normal" development, is increasingly gaining traction (for e.g. Susskind, 2010); such "adaptations" make sense particularly in the resource-constrained urban areas of the developing world. Though allocating exclusive funds that target climate-change adaptation would certainly be advantageous, the reality is that the additional resources required to carry out adaptation-specific measures are simply not available. Moreover, as discussed earlier, local agencies are pressured to focus principally on development to accommodate rapid urbanization. Basic concerns such as clean drinking water and provision of basic sanitation naturally assume far greater importance in policy formulation than does adaptation-specific planning. In such cases, the same resources that would be used in pursuing normal development could be better employed when the initial planning is evaluated with the explicit intent of increasing each project's adaptive potential; planning for "normal" development without considering its adaptation potential may provide only negligible adaptation benefits and result in poor resource utilization. Therefore, in the context of resource-constrained environments, planners should be "looking for public investments and resource allocation choices that make sense for other reasons" (Susskind, 2010).

As discussed in the previous chapter, formal adaptation planning is all but absent in Kolkata and Dhaka. Thus identifying and evaluating opportunities for incorporating water-related adaptation efforts in ongoing "regular" development projects, especially those measures that do not entail substantial additional human or financial resources, therefore confers considerable advantages. My research thus investigates such "adaptation opportunities" which are coupled with larger developmental planning endeavors in the two cities, those that do not generally require additional resources other than the pool already allocated for ongoing development. Moreover, my analysis of these projects clearly shows that the adaptations that are taking place are generally incremental in nature.

Additionally, from a theoretical, policy, and practice-oriented perspective, both understanding the factors that hinder or enable the efficacy of such projects, can distinguish effective predictive indicators for guiding the course of adaptation strategies that can be effective in resource-constrained mega-cities of South Asia.

Chapter Outline

This chapter highlights the results of my field research and draws principally upon the analysis of semi-structured field interviews that I conducted in Kolkata and Dhaka during December-January, 2010, 2011 and May-June of 2012. These interviews were conducted with a range of people including key governmental, officials at the state and local levels, environmental experts, academics and private citizens who were involved in these efforts directly or indirectly.[1] In addition, field observations, informal dialogues and meetings, related secondary sources such as internal organization communications, periodicals, newspaper articles, planning and policy documents, and academic research, augment this work.

This chapter is divided into two sections: *Analysis of Adaptation Strategies* and *Implications for Theory and Practice.*

Under the "Analysis of Adaptation Strategies" I provide an analytical narrative for the three projects, where" The Dhaka Integrated Flood Protection Project" addresses Flood Management, "East Kolkata Wetlands Project" addresses Wetland Protection and Management, and the "Turnaround Program" addresses issues of Water Supply and Management for Dhaka city. All these projects have been selected based on the criteria that they successfully address some larger issues of development while having some adaptation components as well, which are at large enough scales to make an appreciable difference in alleviating climate risk. Additionally, for each project, the planning agencies have also been able to find ways to overcome the

[1] The identity and/or titles of the interviewees have been kept confidential as per their requests. See appendix 1 for a full list of interviews.

challenges arising from existing resource constraints, barriers to coordination and implementation, or have made unique institutional modifications to support such "adaptation" action; these strategies are unique to each case.

In the section following, which pertains to "Implications for Theory and Practice" I develop an argument based on the findings of how these projects not only address adaptation through other larger planning initiatives, but also try to establish some common pathways through which similar projects can overcome some of the key challenges for planning activities in South Asia.

The principal research questions of this dissertation guide the analysis of the three illustrative projects explored in this chapter:

In the face of existing resource constraints, what adaptation approaches have most effectively enabled these cities to respond to the risks related to climate change?

> *How have the local planning agencies overcome the various resource and institutional constraints inherent in planning activities in cities of South Asia to further such adaptation action?*

In answering the research questions, the aim of this chapter is two-fold:

- The first is to make a claim that despite the absence of explicit "formal" climate adaptation planning in Kolkata and Dhaka, there are indeed legitimate elements of adaptation occurring within some development-centered initiatives in both cities. The three projects noted above, which relate to the water sector, have been identified, where the analysis of these projects serves to answer the primary research question on the nature of adaptation approaches that are most effective in cities such as Kolkata and Dhaka.

- In light of the urgency in addressing the climate risks that Dhaka and Kolkata face, it is essential that such adaptation-oriented projects are able to overcome the challenges associated with *resource-constraints, institutional barriers* and *implementation hurdles*, which though not unique to such projects, will nonetheless have to be overcome, if these projects are to be successful. Therefore the second aim is to analyze the different ways in which each of these projects have surmounted these associated barriers, to ultimately arrive at a set of tangible guidelines that can inform planning practice across similar cities in South Asia

ANALYSIS OF ADAPTATION STRATEGIES

Urban Flood Management through The Dhaka Integrated Flood Protection Project:

Project Objectives

In light of the extensive damage[2] of the past floods, which affected many developmental sectors of the city, the objectives of the Dhaka Integrated Flood Protection Project (DIFPP) was not only to stop subsequent flooding but was also meant to increase the overall resilience of the city. Thus the DIFPP integrated several larger developmental initiatives such as drainage, environmental and infrastructure improvements, while directly addressing key adaptation objectives related to long-term urban flooding as well.

In keeping with these larger developmental objectives, the flood protection measures (contained in this project), not only included remedial and new construction of a concrete flood wall, earth embankments, sluice gates and pumping infrastructure, but also included elevating the Central Road accompanied by a post-construction maintenance program for all these upgrades. In addition, the environmental improvements focused on several slum upgrades to reduce vulnerability in terms of water, sewer and drainage infrastructure. Another important component of the project was the rehabilitation of the drainage systems and augmentation of existing networks as well, project elements that not only alleviated drainage congestion but also helped with further development of low-lying vulnerable areas (ADB 2002).

Additional Factors for DIFPP's Success

Moreover because the DIFPP has been successfully implemented with

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[2] For instance, the floods of 1998 more than 4.5 million people were affected to varying degrees; while the severely affected lost their homes and were completely dislocated, others lost their means of livelihoods. In addition, the floods also affected the water supply of the city severely, where 44 "official" deep tube-well were contaminated which resulted in an estimated loss of supply of 45 million liters per day, an about 127 million taka to rehabilitate. In 1988, the floods affected about 2 million people and claimed about 150 lives. In addition over 400,000 thousand buildings (residential, commercial and institutional) were badly affected, with the overall damages amounting to over 4.4 billion dollars (Huq and Alam 2003). Major inundations thus mean that potable water and gas become scarce, transportation to and from the city is greatly hampered, and schools, hospitals, and grocery stores are forced to close. In addition, the first floors of a large number of buildings in this area become uninhabitable, while the threat of water-borne diseases increases substantially.

measurable results, it allows for post-facto evaluation to understand how the planning agencies were able to overcome the three key challenges, mentioned earlier. The analytical narrative of the project which follows, explains the key findings (summarized below) in further detail for which the findings are as follows:

- To ensure adequate resources for the timely and successful completion of the project, the *local agencies enabled collaborative partnerships* with various external agencies to gain financial support both at the national level, and from the international donor, the Asian Development Bank (ADB) as well. Moreover, the project while addressing flood adaptation also *coupled some of the existing local planning initiatives* (such as drainage and road improvements), which obviated the need for local agencies to have to spend their own limited funds, had these components been implemented separately.

- To ease issues of coordination and implementation related to the project, the local agencies also *reconfigured their existing organizational structures* to create distinct management units, which represented both national and local agencies. In addition, *specific reporting structures* that were set up during the planning process also helped increase the accountability of the local agencies. These diversely represented units were also organized to *help address the local deficits in terms of technical and human resources.*

- Lastly, the likelihood of the project being actually implemented increased because of two primary reasons. First, the *high visibility* of the project at the local, national at international area as well as the *strong national political support* ensured the commitment of the various stakeholders. Secondly, since the project *addressed multiple concerns*, it also garnered the *support of multiple stakeholders* since a wide range of people (both planning agencies and city dwellers) benefited from the project.

Project Description

Following the devastating floods of 1987 and 1998, the Government of Bangladesh, in collaboration with local municipal bodies and supported by various international agencies, embarked on a comprehensive flood-risk assessment and protection strategy for the entire country. Drawing upon several Technical Assistance [3] studies for greater Dhaka—which were prepared, with assistance from JICA (1991), in conjunction with a drainage master plan (ADB, 2002; Khan, n.d)—a series of FAPs[4] (Flood Action Plans), specifically FAP8A and FAP8B (the DIFPP), were generated for greater Dhaka. FAP8 as a whole was intended as a series of adaptive and developmental improvements, including restoration and construction of pumping stations and embankments, and road and drainage upgrades.

To prioritize the areas that needed urgent attention, FAP8 was divided into two phases, FAP8A and FAP8B[5], primarily because the available resources were insufficient for simultaneous implementation of the entire Plan (Haque, Grafakos, and Huijsman 2010). The execution of the FAP8B plan, which addressed the most densely populated western part of the city (about 87% of the population was settled in that part of the city at that time), began in 1991 and was fully completed within schedule, in 2001. During the catastrophic floods of 1998, the success of the FAP8B produced some measurable results, which were evident when the western part of Dhaka, an area of about 136km^2, remained flood-free. Among the numerous undertakings associated with the FAP8B, the construction of embankments and regulators for national rivers that directly impact Dhaka city (which include the Buriganga and other peripheral rivers), met with particular success in Phase I, as did the elevation of the Central Road. Primarily implemented by the Bangladesh water Development Board (BWDB), in accordance with the FAP8B, the embankments along the city's western riverbanks of the Turag/Buriganga river were promptly constructed and have proven to be successful in limiting inundation in subsequent floods (ADB, 2002). However, because FAP8A has not yet been completed[6], even after 15 years; a large part of eastern Dhaka,

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[3] One of the associated studies included the "Formulation of Land Development Controls and Procedures for Dhaka City". ADB 1991, Manila, which needed urgent attention.

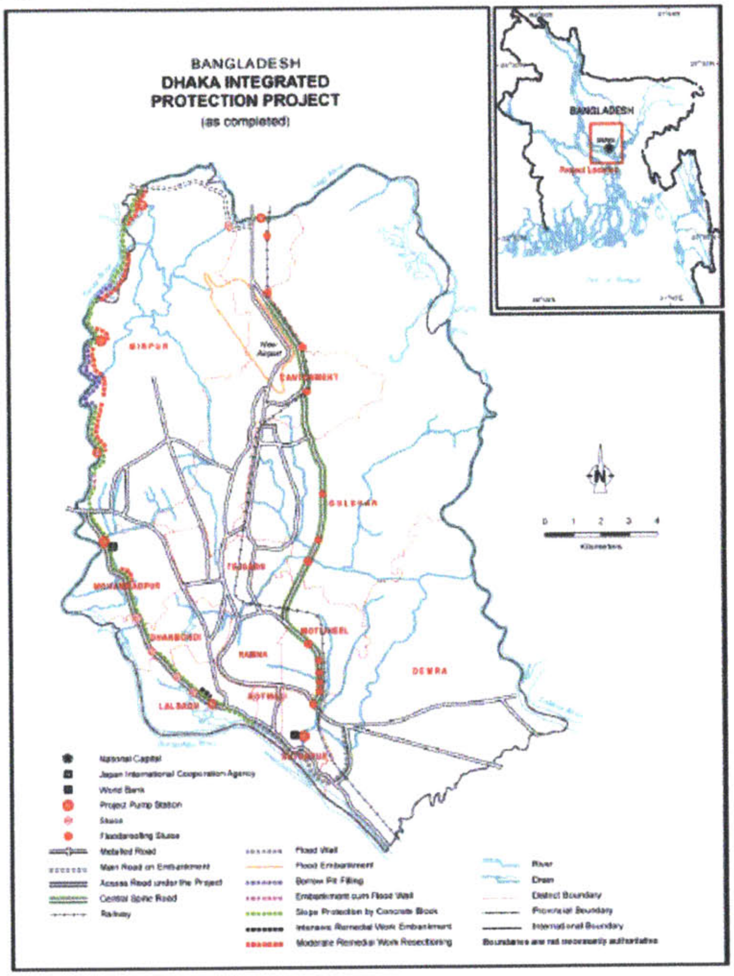
[4] The Flood Action Plans conceived by the Government of Bangladesh consist of a series of feasibility studies and flood-protection recommendations. The FAP is further divided into several components based on the geographical/political boundaries of the different study areas, with FAP8 focused on Dhaka.

[5] FAP8B (Phase I) focused on western Dhaka, and FAP8A (Phase II) targeted the eastern part of the city.

[6] According to a memo submitted to the Ministry of Disaster Management, Government of Bangladesh, which assesses the FAP8, the primary reason cited for the non-implementation of FAP8A to date is the failure on the part of RAJUK (the City Development Authority) in submitting a detailed land-use plan, which includes flood-plain zoning and demarcation of retention ponds, for the area. Such a plan remains critical for the proper planned

about 125 km^2, remained submerged for about two months in 1998 and also faced prolonged inundations in the subsequent floods of 2004 and 2007 (Alam and Rabbani, 2007; Huq and Alam, 2003).

Figure 5.1: The map below outlines major components of FAP 8B (as completed)
Source: ADB, 2002



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development of this area not only for effective implementation of the FAP8A, but also for the adequate provision and augmentation of drainage and sewerage systems, gas supply lines, and piped water supply in accordance with Dhaka's planned development. Currently, in the absence of a land-use plan to guide development, many of the region's canals have been encroached upon and numerous areas have turned into large slums, characterized by inadequate road networks and other infrastructure. During floods or periods of moderate-to-intense rainfall, ground floors of buildings often become unusable, while much of the area tends to retain water and resulting sewage overflows increase the possibility of water- and vector-borne epidemics.

Overcoming Resource Constraints and Increasing Likelihood of Implementation

The project, which cost $159.6 million, was jointly funded by the ADB (about 76%) and the Government of Bangladesh. Three local agencies—DWASA, RAJUK, and DCC—held responsibility for post-project cost-recovery mechanisms designed to defray initial expenses and provide a revenue stream for longer-term maintenance. Obtaining financial resources for the FAP8 did not pose any significant problems for local agencies, which can be attributed to a few related reasons. First, though FAP8B was a city-level project, the national government provided substantial financial support to local authorities, encouraging the participation of major international organizations, such as the ADB. Moreover, the project was given very high priority by the national government and the international donor community; this commitment also ensured follow-up support, as the project inevitably ran over the allocated budget and time frame (Brammer, 2010). During an interview with an official from BWDB, it also became clear that the project was also considered an urgent step in adaptation to urban flooding, principally since it was located in the most populous part of Dhaka city.

> We had to do it. How many more floods could we take? Every time this happened, the city was getting destroyed and so many people were dying. The government had no choice but to find money for the improvements. Besides, we had all the international support. The good thing is that we also were able to improve our drainage system, which had become most necessary.
>
> *(Officer, Bangladesh Water Development Board, Interview 19; translated by author)*

In addition, because of the project's high visibility in the national and international arena, local agencies were able to use this visibility as a political leverage to ensure continued support not only financially but also to make sure that the project was followed through to completion (Interview 29). Moreover, in light of the city's earlier flood-related devastations, domestic and international pressures were also increased to ensure adequate funding and successful implementation. Lastly, since this, was the first phase of the project, the Government of Bangladesh still had the necessary matching funds available to allocate and disburse quickly (Interview 21).

Overcoming Intra-Institutional Coordination and Implementation Issues

As per the guidelines of the FAP for Dhaka city, the Dhaka Integrated Flood Protection Project (DIFPP), was primarily managed by three executing agencies, Bangladesh Water Development Board (BWDB), Dhaka Water Supply and Sewerage Authority (DWASA), and Dhaka City Corporation (DCC), where the former was appointed as the lead agency (ADB 2002). In addition, various other agencies were also allocated responsibility depending on their respective jurisdictions and expertise[7].

The effective reduction in flooding risk resulting from the successful coordination and implementation of the project, despite certain cost overruns,[8] can be attributed to several factors. The clear focus and rational organizational structure for FAP8B proved to be one driver of its success. At the onset, the project scope and implementation arrangements for FAP8B were explicitly demarcated across specific management units such as the Project Steering Committee (PSC). In fact, coordination of efforts at the implementation stage proved to be less of an issue because the final authority for planning and implementation of the project rested with the PSC, which consisted of appointed members from the concerned central ministries.

> They [the local agencies] work better when they report to higher authorities [national level agencies such as the BWDB]. Besides, the prime-minister's office was paying close attention to the progress of the project which made everyone [all local and national agencies involved in the project] more alert. Because of ADB, we had all the implementation and reporting schemes decided upon even before the project started which reduced the confusion that is generally always

[7] These components included: overall flood control and drainage, under the purview of the Bangladesh Water Development Board (BWDB); improvement and augmentation of flood-free transportation links, managed by the Roads and Highways Department (RHD); improvement and capacity enhancement of storm water drainage, including pumping stations, which fell under the charge of the Dhaka Water and Sewerage Authority (DWASA); environmental management and flood-plain zoning, which would be primarily managed by the Dhaka City Corporation (DCC) supported by the Ministry of Land (MOL) and Department of Environment (DOE); and finally the implementation of the Greater Dhaka Master Plan, for which the Dhaka City Development Authority (RAJUK) already held responsibility (Brammer, 2010).

[8] The actual expenditures of $159.6M represent a 33% increase over the budget of $119.8M (ADB, 2002).

> there [referring to projects where several agencies collaborate to work together].
>
> *(Officer, Bangladesh Water Development Board, Interview 20; translated by author)*

As a national agency, the PSC had considerable autonomy during the decision-making process and was thereby able to coordinate and organize local inter-agency efforts effectively. Moreover, the broad authority possessed by the PSC enabled greater scrutiny over and accountability for relevant local agencies. The PSC, chaired by the Minister of Water Resources, also provided the necessary policy guidance and was further supported by two other key bodies instrumental in successful project formulation and implementation. The first was the Project Technical Committee (PTC), headed by the Secretary of the Ministry of Water Resources, which was also comprised of representatives of other national and local agencies; the second was the Project Management Office (PMO), headed by a project director from the BWDB. The PMO consisted of full-time executive staff members from the BWDB and part-time staff from RAJUK, DCC and DOE (ADB 2002). The primary functions of the PMO included overall project coordination and implementation, overseeing programming, financial and tendering management, design and construction, and project benefit analysis (ADB, 2002).

In particular, the inclusion of key staffers from the BWDB in the PMO also greatly improved FAP8B's chances for success. The BWDB had substantial prior experience in the design and construction of embankments across Bangladesh (a majority of them in rural agricultural areas along the coast), reducing the uncertainties in management of related aspects of FAP8B. This experience meant that the BWDB already had the necessary internal human resources and technical expertise to carry out these components of the plan.

Analysis of the overall data suggests, that FAP8 was largely successful in overcoming the general paucity of technical, financial and human resources generally felt by local agencies when undertaking major projects, particularly one as complex as this one, because of the strategic vertical and horizontal collaborations. Moreover, stronger accountability to the national government, ADB's clear guidelines regarding reporting structures and implementation ensured smoother co-ordination among different agencies. In addition, the strategic division of responsibilities, based on prior experience of the agencies was an additional factor in ensuring that the project was completed without any difficulties rising from lack of expertise.

Lastly, the project, apart from its flood adaptation components, had a number of immediate developmental components that benefited a wide range of stakeholders, which in addition to the high visibility and strong political commitment further increased the likelihood of this project being implemented successfully.

Urban Wetlands Protection and Management: The Role of East Kolkata Wetlands Management Project

Project Objectives

Though Kolkata has had a late start in its conservation efforts, which began in earnest only after 2002, capitalizing on these earlier isolated efforts, the East Kolkata Wetlands Management Project (EKWMP) has made important strides in the preservation of its urban wetlands.

The proper conservation and management of these wetlands offers three primary advantages that embrace both developmental as well as a range of adaptation benefits:

First, the wetlands in the city function as natural drainage areas and flood-flow zones, thereby reducing the impact of inundation on developed land, due to intense precipitation or drainage congestion. To reduce the extent of urban flooding, preserving wetlands and low-lying flood flow plains thus represents an easier and more cost-efficient option than does the construction of costly flood-control infrastructure such as embankments and pumping stations. To facilitate this, many of the man-made canals have also been de-silted and refurbished to allow for easy flow of storm and rainwater, again an effort principally targeted at reducing drainage congestion. In addition, the canals and some of the sewer trunks have also been extended and rerouted to form larger networks; in some cases the sewer trunks have been directly connected to the larger ponds and lakes that are part of the existing natural wetlands (EKWMA, 2013). This network of connections between existing sewer trunks and canals with the existing wetland system represents an unique and innovative planning strategy (interviews 81, 82, 83 and 90), which integrates both man-made and natural elements to expand the scope of less costly adaptation options, which helps alleviate some of the resource concerns that local agencies of Kolkata face.

Secondly, apart from reducing the load on existing storm drainage systems in the city, the wetlands also serve as a "natural purifier" for approximately 250 million gallons of sewage per day, obviating the need to build expensive sewage treatment plants and pumping stations to service this area and reducing the deleterious impacts of sewage on health.[9] The wetlands thereby act as "sewage farms" that further purify the city's wastewater (Saha et al., 2010).

The third advantage is principally socio-economic in nature; the wetlands support intensive fishing, aquaculture, and farming activity. Water purified through the wetlands is channeled into larger sewage-fed fish farms and ponds, which cover a total area of about 3,500 hectares (~8650 acres); some of the individual fishponds are as large as 70 hectares (~184 acres). In addition, the treated water from the wetlands (particularly those in water bodies that are relatively purified) is used for agriculture in the surrounding areas. These wetlands produce approximately 13,000 tons of fish and 150 tons of vegetables per day, thereby not only serving as an important source of livelihood for over 100,000 residents of the city, but such local food sourcing also keeps food costs low for the city's residents (EKWMA, 2013).

Though the East Kolkata Wetlands Management Authority (EKMWA) coordinates overall management of the wetlands, it is the local Kolkata Environment Improvement Trust (KEIP), which has been primarily responsible for realizing the full range of benefits that these wetlands can offer.

Additional Factors for EKWMP's Success

The reason for the success of this project, which is evidenced in its many benefits (e.g. environmental, developmental and adaptive as described earlier), can be primarily attributed to KEIP's internally generated institutional modifications. In doing so, KEIP has been able to successfully overcome various planning-related barriers that all local agencies, including the KMC of which KEIP is technically a project unit), generally face (see chapter 4) to effectively accomplish the project objectives.

[9] The exceptionally strong biodiversity of the East Kolkata Wetlands produces unusually effective waste treatment. See, for example, Sarkar, S., Ghosh, P. B., Mukherjee, K., Sil, A. K., and Saha, T. (2009).

Analysis of KEIP's actions suggest the following findings which are explained in further detail in the analytical narrative that follows:

- Unlike the local agencies in Dhaka which collaborated with national agencies to seek support from national and international donors, KEIP formed its own semi-autonomous sub-organization (under KMC) by incorporating key personnel from KMC and KMDA who were qualified to work on this specific project. In addition, KEIP also hired wetland and other related environmental experts to bridge the gaps in technical expertise, which was required for many facets of the project. This *allocation of dedicated personnel* (to augment both technical and human resource capacity) ensured that most project components that needed such expertise or manpower, could be addressed in an effective manner. Moreover, to ensure proper mediation between local residents who were affected by the project, KEIP also collaborated with local NGOs to liaison on the agency's behalf.

- In addition to the larger *institutional restructuring*, KEIP also established *project management* and *coordination units,* so that the all parts of the project could be coordinated and implemented in a timely manner. This was particularly essential for two reasons. First the successful completion of the project would fulfill some rather urgent needs for the city (both developmental and adaptive). Second, proper coordination and implementation of the project also ensured that the project could not only be finished within the loan-agreement period, but the outcomes would also be commensurate with the expectations of the donor agency, ADB. This was of specific interest to KEIP as successful completion of this project meant that ADB would extend likely make further loans for similar projects[10].

- Lastly, KEIP also developed some unique *process innovations*, particularly in areas of business accounting and project delivery notification. This

[10] Based on the KEIPs satisfactory past performance, ADB has subsequently supported other projects as well. One such ongoing project if for garbage collection stations for which ADB has allocated 4.5 crore I.N.R. (~US$900K) (*The Times of India*, 2012). Also most recently in 2012, KMC submitted an environmental assessment report for another Water Supply project, which is expected to be implemented by KEIP, pending loan approval by the ADB. To access the full report please visit:
http://www2.adb.org/Documents/IEEs/IND/42266/42266-023-ind-iee-01.pdf.

greatly facilitated the relationships with external vendors, other local agencies and the donor itself where all parties received timely project updates and queries could be speedily resolved; this also helped with coordinating multiple components of the project, helped with project monitoring and enabled timely implementation. In addition the on-line accounting system expedited payments to all outside parties, which encouraged timely completion of the work that was undertaken by sub-contractors.

In analyzing the different aspects of KEIP's modifications, it becomes evident that the project could not have been completed efficiently, nor would have had the continued and active support of the donor, had it not been for the various institutional modifications that aided different aspects of the project. Though such modifications can be applied to other planning projects as well, timely and effective implementation of projects such as the EKWM is critical for cities like Kolkata where both development and adaptation is of prime and immediate concern.

Background

The East Kolkata Wetlands consists of intertidal and salt marshes, salt meadows, lakes, and seasonal ponds, as well as settlement ponds and oxidation basins. These urban wetlands encompass an area of 12,500 hectares (just under 31,000 acres) and comprise one of the largest urban wetland systems in Asia (EKWMA, 2013). Approximately 46% of this area is comprised of water bodies, 39% has been converted into agricultural land, and the rest consists of urban and semi-rural settlements as well as landfills. Because of its unique ecological characteristics and the range of critical benefits that it provides for the city's population, the East Kolkata Wetlands System (EKWS) was deemed a "wetland of international importance", and designated a "Ramsar" site in 2002[11], thereby legally protecting it against future urban encroachment or damage (Ramsar.org, 2013). The protection of the wetlands and its subsequent designation as a "Ramsar" site was largely due to the activism of several prominent environmental experts and NGO groups such as "People United for Better Living in Kolkata" (PUBLIC). Through a process of several awareness campaigns and lawsuits against the

[11] The Ramsar Convention is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. The Ramsar Convention is the only global environmental treaty that deals with a particular type of ecosystem (Ramsar.org 2013).

local and state governments since the 1980s, not only did the state government seek out the designation in 2002, but also enacted the Conservation and Management Act in 2006 which prompted the establishment of the East Kolkata Wetlands Management Authority[12], which further solidified the ongoing conservation efforts (Wetlands International, 2010).

My interview in December 2010 with one of the most prominent wetland experts and environmental activists of Kolkata, who has been a champion of the Kolkata Wetlands for over 20 years, further revealed that the "Ramsar" designation provided the principal impetus for a renewed and active interest in the wetlands. This interest also engendered further research on the benefits of the wetlands.

> All this attention from the government did not happen by itself. We were all behind the movement. There was so much corruption; many of the wetland parcels were being sold to the developers even before the public was becoming aware of it ---parts of Salt Lake, for instance. Did you know that in 1991 we all went to court and filed a writ petition which we won ... that was a big milestone. Before that, there were serious talks of building the New World Trade Center in 1991. ... Ever since the Ramsar designation so much research has been done on these wetlands ... now everybody knows and can actually see how much it has helped the city
>
> *(Wetland expert and environmental activist, Kolkata, Interview 95; Translated by author)*

Though wetlands protection was not part of an explicit "climate adaptation" initiative, it certainly became an integral part of the "environmental" planning agenda for the city where its adaptive benefits were taken into account, especially when KEIP initiated the EKWMP to extend the different applications of the EKWS.

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[12] The EKWMA is a local agency, which was formed through the Department of Environment, Government of West Bengal, India, in 2006. EKWMA is comprised of representatives of different departments from the State government, other public agencies, and three NGOs. The EKWMA holds the primary responsibility of present and future conservation and maintenance of the wetlands in the KMA area, including the East Kolkata Wetlands, and has prepared a comprehensive and integrated Management Plan in keeping with basic guidelines of the Ramsar Protocol, which is currently being implemented.

> Climate change adaptation is a very new thing for Kolkata agencies. I think it will become more prominent after the state releases its action plan. The environmental improvements that we make are both for the future sustainability of the city and to increase the level of development. To answer your question, though we are not calling it "Climate Change Adaptation", all the drainage and sewerage improvements that we [KEIP] are working on, will all help with the flooding of the city. The EKWS project is also a natural drainage system and we have maximized the areas for retention ponds
>
> *(Senior Official, Kolkata Environment Improvement Trust, Interview 86; Translated by author)*

Moreover, once decision-makers understood that the wetlands also helped with the drainage congestion and, for some areas, obviated the need to build additional sewage treatment plants and pumping stations, the city planning agencies, particularly Kolkata Environment Improvement Trust (KEIP), the implementing agency of KMC, actively engaged in developing and refurbishing the existing wetlands infrastructure. This external spur for wetlands protection helped to further augment the uses of the wetlands and preserve them (Interviews 82, 85, 86 and 89).

Organizational Structure

KEIP is a multi-agency endeavor, which was established as an independent, project-based organization (of KMC) in 2001. The agency is involved in the planning, coordination, and implementation of a range of projects, which have been noted as some of the most effective climate- and environment-related planning efforts in the city of Kolkata (Interviews 81, 83, 88, 94 and 96). In addition, it also seeks to improve the "governance and service delivery mechanism of the Kolkata Municipal Corporation" (KMC), which is one of the principal local planning organizations of Kolkata (Interview 81). KEIP is jointly funded and monitored by the ADB, the Government of West Bengal, and the KMC.

Activities

Some of the major ongoing or completed projects associated with the urban wetlands in Kolkata address the following concerns: sewerage and drainage, solid waste management, and canal rehabilitation. Specific measures include de-siltation of existing storm and sewer lines, construction and rehabilitation of sewage pumping stations and treatment plants, and planning and construction of new sewage and storm water networks (KMC, 2010). In the management and preservation efforts for the East Kolkata Wetland Systems, KEIP also collaborates with the East Kolkata Wetlands Management Authority (EKWMA) and the Centre for Environmental Management and Participatory Development (CEMPD), an NGO affiliated with KEIP[13]. This collaboration also entails allocation of human and fiscal resources as well as the safeguarding of various stakeholder interests.

KEIP's Institutional Modifications

The successful completion and sustained positive impacts of some of these projects across both developmental and environmental dimensions stem primarily from the overall *institutional restructuring* and *allocation of dedicated personnel resources (technical and human)* for specific KEIP projects. KEIP was structured, and functions as, a stand-alone "planning" body that encompasses a number of complementary units, with authority over design and supervision, project accounts, social development, public relations, and project coordination and management. Each of these units has well-defined responsibilities and is staffed by KMC officials and engineers, experienced external engineering, technical and environmental consultants, and managerial experts from relevant private-sector enterprises. The clarity in KEIP's structure, and particularly in the augmentation of in-house expertise by hiring key technical professionals, has been key to overcoming barriers to coordination and implementation of some rather specialized projects.[14]

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[13] Though termed as "environmental", these projects also address many climate-adaptation risks, including flooding, while remaining part of the "regular" developmental agenda. The environmental projects initiated by KEIP have been further vetted through the eight evaluative criteria that I have formulated after conducting the field research for this work. Almost all the projects meet at lest five of those criteria.
The criteria are as follows:
i) Does the project address any local climate risks?
ii) Does the project tackle any planning, developmental, or infrastructural objectives?
iii) Were any explicit policies or planning measures to deal with these climate risks already in place before the project commenced?
iv) Were the climate risks assessed prior to the implementation of the project?
v) Were new objectives integrated into existing projects to manage climate risks?
vi) Are there any specific metrics or standards for the success of the project?
vii) Does the project display any synergies among the involved sectors?
viii) Did the project lead to any social benefits or innovations?

[14] Examples of such projects include managing the eco-system of the East Kolkata Wetlands while simultaneously de-silting a majority of the canals and constructing, upgrading and rehabilitating solid waste pumping stations, treatment plants, and secondary and trunk sewer lines.

Additionally, representatives of NGOs are engaged by KEIP to ensure the participation of those private citizens directly affected by the project(s) and to serve as mediators as necessary, which has reduced the conflict between wetland squatters and the local agencies.

> The NGO people have been very helpful. In many cases, where otherwise the project would have been delayed because the local people refused to move, we have been able to come up with some compromises, which has been good for both parties. The NGO representatives go around to inform the affected "villagers" about the projects that are happening and the benefits that they will receive. Our [KEIP] engineers would not have had the time or patience to do so. Last year we needed to deepen an existing trunk canal so that water could flow easily into the ponds. However, the "villagers" had built wooden bridges to gain access to their huts over the canal. This meant that they would lose access to their homes if we were digging it [the canal] up since we would have to remove the bridges that they had built. However, the NGO negotiated a plan to do this part by part so that KEIP could provide temporary bridges, as needed, for continued access. This worked out very well and we were able to complete the work without any delays. It looks like the poor people seem to trust the NGOs more than us, as the poor think we are not on their side, but you know this is not true. After the work, we put in our own money to build the bridges back
>
> (Senior Official, Kolkata Environment Improvement Trust, Interview 86; translated by author).

KEIP is also headed by an administrative officer who is appointed on a transferable basis from the Indian Administrative Services (IAS) pool of central government officers. This reliance on outside senior management ensures that the administrative head functions as a neutral party, one who is not personally vested in the politics or projects of the state or city.

> In Kolkata many of our special project units [such as KEIP] and in agencies like KMDA, the government is now appointing officers from the IAS cadre as administrative heads. I think it is because we [IAS officers] have a reputation of being less corrupt. ... Our job is also transferrable at any time depending on the ministers, which can be a good thing or a bad thing

(Official, IAS cadre, Kolkata Environment Improvement Trust, Interview 81)

According to some other interviewees in Kolkata, the case of KEIP demonstrated that this approach succeeded in minimizing the politicization of KEIP's plans and policies, and that such decisions have proven particularly useful in societies such as India that struggle with endemic corruption and lack of transparency (Interviews with KMDA officials).

Another factor that has contributed to the success of planning efforts in this area has been the presence of effective, clearly delineated *project management* and *coordination units* within KEIP. The establishment of these units has enabled smoother implementation of projects and greater accountability and success in project delivery, liaison and inter-agency collaboration among multiple state and city agencies[15].

> Everything is in-house [at KEIP]. This means that we do not have to deal with coordination problems and can get everything done on time and without interference. We have the engineers and officers [we need] represented from the different local agencies, so that no [local] agency can say that they are not part of it. This works very well. We even separate units to manage project implementation.
>
> (KMC engineer on deputation to KEIP, Interview 90; Translated by author).

An additional element that has proven instrumental in facilitating project coordination, implementation and monitoring is KEIP's *process innovation,* in the form of its computerized "project accounting system". This system has been tailored to fit the requirements of the types of projects undertaken at KEIP and to correspond to the organization's level of technical expertise. This fully digital interface, functions as an integrated Business Process System, with built-in controls to ensure accountability and timely and accurate disbursal of payments, in addition to providing "information visibility and workflow-driven approval hierarchy" (PSP Financial Consultants http://www.taxilaonline.com/index.php). This technological innovation at KEIP

[15] Some of the agencies with which these units must coordinate policy and action include: the West Bengal Pollution Control Board (WBPCB); the Departments of Environment, Forests, Fisheries, Irrigation and Waterways, Transportation, Land and Land Reforms; local and state police departments; the BSNL (Bharat Sanchar Nigham Ltd., the telecommunications giant); CESC (the Calcutta Electric Supply Corp.); WBSEB (the West Bengal State Electricity Board); the District Administration; and the KMC and KMDA. The creation of these units has greatly aided in managing such wide-ranging organizational relationships.

has succeeded in shortening project-delivery time, facilitating communication among different public agencies and private contractors, and in minimizing the bureaucratic delays that have long characterized the functioning of India's public-sector entities (Interview 81). Though the project accounting system does not directly aid adaptation planning, such institutional innovations for adaptation or otherwise, greatly increase the chances of successful project delivery in Indian cities. In the case of execution of environmental projects in Kolkata, such as, alleviation of water-logging, it is essential that such adaptive planning be completed as soon as possible, especially in light of the increasing frequency of climate events that the city has been experiencing.

A majority of the interviewees cited the process of *collaborative consultation* with environmental and technical experts who possess extensive knowledge of local needs and conditions, as an important element in furthering the success of the KEIP projects.

> We selected our environmental consultant [environmental engineer specializing in biodiversity], the minute we got keys to our new office [KEIP]. He [the environmental consultant] had done his Ph.D. from America but came back to Kolkata a long time back, so he knows the area well. He is now part of our team and has been with us since we started the project. We do not even think of him as an outside person and his expertise has certainly helped. [For example], ... now we know level of "turgidity" in each of the ponds so that we farm fish only where it is safe.
>
> (Project Director, KEIP, Interview 85; translated by author).

The fact that "experts" were brought in at the beginning of most of the projects and were also employed full-time by KEIP for the duration of each particular project helped in a number of ways. First, the consultants and regular staff had an opportunity to develop the plans and implement them collaboratively, right from the project's inception through to its finish, while being able to make necessary adjustments along the way. Second, since some of the experts were members of the KEIP project teams from the outset, they also felt more deeply invested in the projects' success, finding new and innovative ways to deal with problems "on the ground" throughout the projects' course. Third, this model of collaborative consultation allowed for continuous dialogue and expert guidance, thereby reducing the opportunities for hierarchical conflicts. Such conflicts are much more likely to occur with one-off expert consultations, since the regular employees often perceive the experts' involvement as an imposition and thus often either ignore the consultants' input during the actual planning stages or reject the outsiders' recommendations as unrealistic.[16] Fourth, having expert consultants employed as part of the project teams helped to fill the inherent gaps in "technical expertise" and thus increase KEIP's overall institutional capacity (Interviews 82, 85, 86, 89 and 90).

In several ways, KEIP appears to serve as an exemplary model of institutional innovation particularly in the ways it has restructured itself to overcome barriers of coordination and implementation as discussed earlier; such institutional initiatives remain uncommon in the public sector organizations in Kolkata.

Though the ADB's conditions[17] certainly served as a catalyst for some of the institutional changes, many of the other innovations did stem from internal considerations and careful forethought. According to the Managing Director of KEIP, Mr. Suswit Biswas (Indian Administrative Services (IAS), the organization's internally generated reforms, which also became major contributing factors in crafting effective strategies, include:

- Implementation of a substantial organizational restructuring while ensuring appropriate and balanced representation of relevant public agencies.
- Development of a realistic planning process that takes into account issues of design, coordination, financing, and implementation at a project's onset.
- Adoption of technological innovations, such as the computerized project accounting system, that enhanced transparency and reduced bureaucratic delays.
- Employment of collaborative consultation to decrease technical deficits while increasing overall institutional capacity.

[16] See, for example, Ben-Gal, H. C. and Tzafrir, S. S. (2011), *The Times of London* (2005) and Glen, P. (2002) for further discussion on consultant-client relationships.

[17] It is important to note, though, that the conception and implementation of these institutional innovations did not occur solely because of internal forces. The formation of a separate project-based organization, the hiring of experts to augment institutional capacity, and KEIP's extant implementation and accountability guidelines and processes were endogenously mandated by the contractual conditions imposed by the Asian Development Bank (ADB) as part of its loan agreement with KMC (ADB 2002).

Ensuring Water Supply and Quality through Dhaka Water and Sewerage Authority's Turnaround Program

Project Objectives

According to its Investment Plan outlined in the "Turnaround Program", Dhaka Water and Sewerage Authority (DWASA) has earmarked US $1.6 billion through 2021 for infrastructure projects and improvements in the water sector. DWASA has also made significant financial commitments to most of these projects in addition to securing loans from the Government of Bangladesh, World Bank, ADB, and Danish International Development Assistance (DANIDA).[18]

These improvements include four surface-water treatment plants:[19] Saidabad Phase II, Saidabad Phase III, Padma/Pagla,[20] and Khilkhet. Of these four plants, the Saidabad Phase II project was completed in December 2012, six months before schedule and within the allocated budget of Tk 1,140 crore ($170M), with a capacity of 2250 MLD/day. The construction of Phase III has already begun with additional assistance from DANIDA, which recently

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[18] The principal focus of support from the federal government and international donors remains on improving supply management and service delivery for DWASA through technical assistance, grants, and loans. DANIDA and the Swedish International Development Agency (SIDA), for example, are considering funding a doubling of the capacity of the existing surface-water treatment plant at Saidabad. The World Bank, in conjunction with the ADB, is currently assisting DWASA with wastewater management, storm water drainage, water supply and sanitation services to low-income communities, social and environmental safeguards, and the DWASA Performance Improvement Plan. The Asian Development Bank also worked with the national government in preparing the Dhaka Water Supply Project, which included the master planning of Dhaka's water supply, detailed designs for tube well rehabilitation and distribution improvement, and the institutional development of DWASA (ADB, 2006). The Department for International Development (DFID) moreover is working with DWASA on slum improvements and institutional development. In addition to these bilateral institutional donors, some NGOs, among them Water Aid and Dustha Shastha Kendra (DSK), are collaborating with DWASA to provide potable water for slum dwellers, conservatively estimated at 15% of the city's population (World Bank Sustainable Development Unit, 2007).

[19] The treatment plants will process water obtained from some of the less-polluted rivers around the city, from up to a distance of 60 km from the city.

[20] Further details on the Padma Treatment Plant Project are available at Globalwaterintel.com: http://www.globalwaterintel.com/archive/12/4/general/dhaka-plans-16bn-boost-water-treatment.html.

(December 2012) pledged another $100M for implementation. The treatment plants, when fully functional, are designed to replace about 70% of Dhaka's groundwater supply with purified surface water.

This plan to transition to surface water supply is an important step in climate adaptation in the water sector. According to Dhaka Water Supply and Sewerage Company (DWASA) authorities, as of April 2012, the projected demand for fresh water for the city was estimated at 2.25 million cubic meters per day (2250 MLD/ million liters per day), of which only 2.11 million cubic meters per day (2110 MLD) is currently supplied.

In addition to this overall deficit in water supply, currently, over 87% of Dhaka's water supply comes from over-exploited groundwater aquifers; there are over 2000 private tube wells in the city and 600 run by WASA (Haq, 2006). What is rather ironic in the case of Dhaka is that, even though adjacent rivers provide ample surface water, much of it remains unusable because of severe industrial and residential pollution over the years.

With the rapid rate of development in Dhaka, increased surface run-off, reduction in water tables and the quality of groundwater being compromised by salinity intrusion, all effects aggravated by climate change, this overreliance on ground water for Dhaka is becoming increasingly problematic (MOEF, 2008; Climate Change Cell, 2009). Thus, as mentioned earlier, the surface water treatment plants are a necessary component of adaptation in the water sector.

Moreover, while Dhaka's groundwater generally meets WHO safety standards in most areas currently, poor maintenance of underground supply pipes has allowed for seepage of contaminants into the drinking-water supplies of the city, further deteriorating its water supply. To address concerns related to poor infrastructure, apart from the projects that specifically address long-term adaptation in the water sector, such as the switch to surface water treatment plants, DWASA has taken the lead role in several other infrastructural projects in the water and sewer sector[21] to address these additional problems

[21] Such projects include: construction of deep bore-wells in areas which have uncontaminated groundwater resources from which water cannot be piped easily; rehabilitation of 44.8 km of old water lines and building of 51.6 km of new water lines to reduce contamination (2011); construction of pre-treatment facilities for waste water treatment plants to support dry-season operations; and provision and upgrades for permanent backup generators to ensure uninterrupted power supply to water pumps during power outages (ADB, 2013). http://www2.adb.org/documents/reports/consultant/ta-4651-ban/feasibility-study.asp#a2

as well, which is strongly reflected in the enhanced water supply situation of Dhaka in the past two years.

Additional Factors for the Success of the Turnaround Program

The DWASA Turnaround Program is not only an important step towards augmenting the overall water supply and quality for Dhaka city (through various infrastructure improvements and expansions), but components such as augmentation of surface water supply, water conservation efforts and preventing contamination through infrastructure improvements, constitute important adaption efforts.

As in the case of DIFPP and EKWMP, the Turnaround Program for Dhaka has also been successfully completed largely because of DWASA's institutional reforms, which represents a critical reason for its planning achievements. No matter how good the available adaptation options are, they are useless if they cannot be successfully implemented. Correspondingly, in the case of the Turnaround Program, without DWASA's institutional reform, the project could not have succeeded.

Along these lines, analysis of DWASA's activities supports the following findings, explained in further detail in the analytical narrative that follows:

- Unlike the earlier cases in which local agencies either collaborated with other organizations or incorporated additional representatives to advance the specific projects, DWASA increased its institutional efficiency through *internal reform.* These steps included significant increase in its *operational efficiency* through reduction of manpower and streamlining its functions by removing functional redundancies. Additionally, this operational efficiency helped to conserve existing revenues, which contributed to the agency's current financial autonomy.

- Moreover, though a public agency, DWASA modeled itself after a private corporation and took several steps to gain autonomy both financially and administratively. [22] Such autonomy in turn *increased organizational flexibility and overall authority* in coordinating and implementing its projects.

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[22] The WASA Act of 1996 clearly demarcated the roles and responsibilities of the organization; the Act also gave the agency sufficient autonomy to make its own decisions. In the last two years, DWASA has taken additional steps to increase its independence.

- The financial autonomy resulting in surplus revenue has since made it possible for DWASA to invest in its own projects, many of which have similar adaptation components as the Turnaround Program. The agency *increased its revenue generation* through many distinct independently initiated actions:
  - First, by increasing its overall efficiency and removing functional redundancies, DWASA was able to save money in its day-to-day operations.
  - Second, the agency increased its revenues by broadening its service area through infrastructural improvements and expansion.
  - Third, DWASA significantly reduced its non-revenue water (water loss from leakages and water theft), thereby dramatically increasing its revenues from the now-reclaimed water supply.
  - Fourth, the agency increased a computerized billing system to ensure revenue recovery in a timely manner. In other service areas, where DWASA did not originally have the human capital to collect revenues, it hired outside agencies to expand its revenue collection.
  - Lastly, because of its service improvements, DWASA was able to justify increases in its water tariff, which likewise increased overall revenues.

- DWASA also increased its *institutional capacity* and overall performance of its employees by providing additional training and revising its training and operating manuals to reflect the improved processes.

- The agency also took steps to increase its *accountability* to its customers by providing regular service updates, establishing an online and telephonic complaint cell, and enrolling in national performance monitoring and improvement programs to create additional external accountability. In addition, the agency has also increased in *transparency* by maintaining an online database of its annual financial statements as well as complete records and status of its projects.

- DWASA has also initiated an awareness program in the city to encourage water conservation. In addition, it has also conducted and participated in several workshops and conferences to share its experiences with other water agencies both in the country and abroad.

Background

Dhaka, like many megacities of the developing world, faces severe shortages in fresh water supply. Though the specific impacts of climate change on water supply varies from region to region, the fact remains, however, that in rapidly urbanizing cities such as Dhaka, where approximately 16.4 million people reside within 300 km^2, fresh-water scarcity, particularly potable water, is a compelling and growing problem (Rahman, Islam, and Al-Muyeed, 2011).

Dhaka's water supply, like most other cities in the developing world, has been affected seriously by growing climatic risks and severe hazards. After the 2004 floods, the Daily Star, one of Bangladesh's leading newspapers, captured the fallouts of these deleterious impacts of climate hazards in one of its reports:

> **Flood-hit Dhaka reels from water crisis:** A late July newspaper report during the 2004 flood noted that more than 2 million city residents faced an acute drinking water crisis as supplies had become contaminated. Thirty water pumps operated by the Dhaka Water and Sewerage Authority (WASA) were inundated by rising floodwater. Water pipelines stretching over a few hundred kilometres and many reservoirs were also under water, posing a serious threat to public health. Floods had already affected more than 5 million people or half the total city population. People in 18 out of 22 thanas were marooned at that point (*The Daily Star*, 2004, For full article please see http://www.thedailystar.net/2004/07/26/d40726250114.htm

In light of these problems, a feasibility study[23] conducted by external consultants for ADB, in preparation for a loan for "The Dhaka Water Supply Project" 2006, found crucial weaknesses in DWASA's operations. Some of the weaknesses relevant to the discussion include i) inadequate supply of clean water to meet rapidly growing demand ii) Poor quality of water distribution network iii) Poor quality and reliability of water iv) Inefficient or

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[23] The study involved inputs from various groups involved in, and affected by, the city's water problem—the government, DWASA, the utility's union groups, civil society, and consumers. Their contributions have helped inform the consultant's Draft Final Report of the feasibility study. In the final months of 2006, this Draft Final Report is being presented to the various stakeholder groups for feedback and suggestions before finalization (ADB 2006). For related factsheet please see http://www2.adb.org/Documents/Reports/Consultant/ta-4651-ban/Factsheet.pdf

ineffective management systems and v) Financially unsustainable utility (ADB, 2006)

Following the findings of this study and prompted by the city's rapidly growing population and increasing risks from climate change in the water sector, DWASA has since made significant strides to address these challenges and reform itself to effectively address the larger issue of water quality and long-term water security for the city. To accomplish these objectives, in the last two years, the organization has found ways to address these challenges, which include overcoming its resource constraints, enhancing institutional efficiency and capacity through innovative practices, and planning for and successfully completing the construction of its latest surface-water treatment plant[24].

Institutional Enhancements to Increase Productivity and Efficiency

In terms of *institutional reform and innovation*, particularly in the context of developing world cities, the "Dhaka WASA Turnaround Program 2010-2012" has been recognized[25] as a unique effort in increasing institutional capacity, transparency, accountability, and operating efficiency. Moreover, it became evident from the interviews with DWASA's personnel that they were quite aware of how crucial a robust water supply system was for the long-term sustainability of their city and for increasing Dhaka's resilience, given the severe and relatively floods the city has been experiencing (Interviews 27, 28, 29, 31, 32 and 33).

> We have no time to waste...If we are going to tackle this challenge [Dhaka's water insecurity] then we had to have our own resources and become a self-sufficient and efficient company...This also meant that we had to expand our networks and cut down on our water losses in the system
>
> (Md. Taqsem A Khan, Engr., Managing Director, DWASA, Interview 28)

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[24] Of the four surface-water treatment plants that were approved for construction, the Saidabad Phase II project was completed in December 2012 within the allocated budget and six months ahead of schedule.

[25] DWASA received the "Performer of the Year Award" at the Global Water Summit, 2011, in Berlin for its outstanding achievements.

Although DWASA is a public-service enterprise, the agency operates in a manner similar to a private commercial enterprise, in that DWASA generates its own revenue, establishes its own budgets, and operates independently.[26]

> Now we run our agency like a company very much like in the corporate world and this structure is unique in Dhaka [as compared to other local public agencies]. We are financially autonomous now and set our own budget, so we are able to make decisions independently without any outside interference. This year we increased our revenues even more
>
> (Md. Taqsem A Khan, Engr., Managing Director, DWASA, Interview 28)

In the past two years, the company has managed to streamline its operational processes while still ensuring quality service, resulting in much-needed additional cash flow (Interview 29). Overall, the operational efficiency has gone up to 0.79 from 0.9 in the past two years while the company hopes to achieve a target of 0.7 within the next six months [27] (DWASA- www.dwasa.org.bd/*). This increase* in efficiency is also reflected in DWASA's published organizational chart, which showed a decline in total headcount from 4,431 in early 2010 to 3,294 by June 2011. An interview with the Managing Director of DWASA revealed that the company was able to achieve these operational efficiencies through identifying the redundancies in the organization and combining many overlapping functions between the water and sewerage departments, among other measures.

In order to build additional capacity and optimize operational performance, Dhaka WASA has also made appreciable efforts to invest in its employees.

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[26] Dhaka WASA was established in 1963 as an independent organization and reorganized under the Dhaka WASA Act of 1996. The organization functions semi-autonomously under a Board of Directors and answers indirectly to the Ministry of Local Government, Rural Development and Cooperatives (LGRD&C). The Dhaka WASA Board assists in formulating policy and guiding strategy. DWASA is administered by a Managing Director and four Deputy Managing Directors, including a Chief Engineer & Commercial Manager. DWASA is organized into four divisions—Administration, Finance, Operation & Maintenance, and Research, Planning, & Development—with a separate Office of the Chief Executive (Managing Director).

[27] Operational efficiency is a measure of business productivity. It is calculated as a ratio of input to output, so the smaller the ratio, the greater the operational efficiency. The input variables, for instance, may include operating costs, headcounts and time, while outputs may encompass revenue, headcount productivity, customer loyalty, number of customers, customer equity, and performance improvements. For a more detailed discussion see: Coelli, Rao, O'Donnell and Battese (2005).

Specific measures have included upgrading its training facilities, revising its training modules to reflect process reforms, and providing continuing education programs. In addition to substantial reforms in its internal organization and operating procedures, the agency has also adopted various new technologies to increase its efficiency, accountability and transparency. For example, the agency is currently in the process of developing a GIS-based Management Information System for digital archival and retrieval of available data. In addition, it is also creating a distribution system model of the city water and sewer infrastructure to increase its capacity for system evaluation, operation and planning (DWASA online documents and interviews 26, 29, 31 and 33).

Within the last two years the organization has also adopted a fully digital accounting system to ensure efficient, timely, accurate billing, electronic revenue collection, and rapid retrieval of customer records. In addition, by the first quarter of 2010 the company had a fully operable Help Desk and Complaint Cell both in the headquarters and in it's zonal offices, the first of it's kind at the local level in Dhaka.

In addition to service-related customer outreach, the agency has also created programs to increase public awareness of its work through various media. The agency's website is regularly updated to reflect ongoing improvement projects and provides information about water- and sewerage-related issues and interruptions.

> Our customers are very happy with us. Just like how it is in Western countries, they [the customers] can reach us directly by telephone during office hours and access our website around the clock every day of the year. Our website is updated by our website team so that the customers can get immediate information on any service problems in the city
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> *(Director, DWASA, Interview 30; translated by author).*

DWASA also has giant billboards in prominent locations throughout the city and other print campaigns to encourage water conservation[28]. In addition,

[28] DWASA has also formed close partnerships with several NGOs and community organizations to plan for and manage water supply around Dhaka's informal settlements. Currently, though such outreach is still at a "pilot" stage, the agency has plans to expand such efforts city-wide in the next two years.

DWASA has now organized and participated in many conferences[29] and workshops where several local agencies exchange information on best practices and form collaborative teams to provide mutual assistance and share experiences.

> Seeing our good performance, WASAs of Chittagong and Khulna (other major cities of Bangladesh) and others wanted to know the secret to our success and see whether they could learn from us and create an educational exchange forum – so we are organizing conferences to increase awareness. We have not had proper feedback about how much this has helped, but it is a good start and we had good discussions
> *(Senior Director, DWASA, Interview 29; translated by author).*

Another commendable initiative is DWASA's participation in the "Program for Performance Improvement", in which the company has convened a Benchmarking Committee to monitor its ongoing performance. He further noted that

> This [the program] has really helped with our performance. The more people know what we are doing the more support we get for our projects. .... As we are becoming better as a company ...you can see our services are also improving. Dhaka's water supply is definitely going to become one of the best in the region [He was comparing DWASA to other cities of the developing world including Kolkata]

The Committee, which consists of senior staff members and is headed by the Managing Director of DWASA, works in consultation with representatives of the World Bank, ADB and the South Asian Water Utilities Network (SAWUN) and meets regularly with concerned stakeholders.

[29] One of the major conferences, 'Surface Water: The Future for Dhaka WASA' which dealt directly with adaptation in the water sector, was organized by DWASA in February 2011. More recently in April of 2012, DWASA was the major contributor in a workshop titled, 'Sharing the Turn Around Program of Dhaka WASA and Networking for Inclusive Water Supply in Large Cities', where many local planning agencies around the country participated as well. For further details on the participants and full proceedings please see visit www.dwasa.org.bd/. Again in May of 2012, DWASA was invited as a special guest to speak about their ongoing work in a major conference organized by the Government of Bangladesh titled, 'Transparency and Integrity in Water Supply in Dhaka City: Challenges and Way Forward'.

Revenue Generation

DWASA has instituted a multi-pronged strategy to increase its revenues. According to DWASA's new plan to streamline its fiscal functions, the agency has created eleven revenue zones and set a zone-wide target for billing and reductions in the amount of Non-Revenue Water (NRW—illegally obtained water supplies), which is a common problem in most South Asian mega-cities (ADB, 2006). In some of these zones, the utility staff is directly responsible for these items while in others (depending on the gap in capacity), many of the revenue functions are contracted to the Employees' Consumers Supplies Cooperative Society Ltd. (ECSCSL).

Apart from its overall structural reorganization to streamline revenue generation, DWASA has utilized its computerized billing system, on-time billing and recovery, twenty-four-hour SMS and web-based payment methods to boost its revenue recovery by 92% in the past two years.

Another area in which the agency's efforts have paid off, has been in the reduction of Non-Revenue Water (NRW), in addition to finding effective ways to increase overall revenues. In targeting new revenue streams and combating the problem of NRW[30], DWASA has reduced system leakages, installed new meters, implemented accurate billing procedures, expanded its outsourcing base for billing collection, increased water supply and supply networks, regularized illegal connections, and established a system for annual tariff adjustment to account for inflation. These changes have shown appreciable results; NRW decreased from over 40% of total flow to 29% by the third quarter of 2012 and overall revenues rose by 25% (Annual Report-2011, DWASA-www.dwasa.org.bd/*). According* to the last fiscal year report (2011), the net revenue rose by one billion taka ($9.4M) over 2010, bringing total revenue to five billion taka, with a tariff adjustment of only 5% in July 2010. Despite the increase in the agency's revenues and escalation of its services, water costs in Dhaka still remain among the lowest in the major cities of South Asia.[31]

[30] To enhance its external accountability, DWASA has also entered into a five-year (2008-13) performance agreement with the central government designed to reduce the NRW to 25%, a realistic "optimum" level.

[31] In November 2011, the metered residential tariff was 6.6 Taka ($0.09) per cubic meter. For households with sewer connections the tariff was 13.2 Taka ($0.18) per cubic meter. Unmetered residential water connections were billed at 128 Taka ($1.72) per month. The commercial, industrial, and institutional tariffs are more than three times higher.

DWASA's success cannot be attributed merely to the organizational reforms or financial security. Rather, its willingness to reexamine and innovate its processes, thereby engendering dramatic and swift institutional was also possible because of its visionary leader. The Managing Director of the agency, Taqsem A. Khan, has been noted as a champion for his agency; such inspirational management is lacking in most comparable organizations (Interviews 2, 8, 9, 29, 30, 33 and 38). Finally, it is worth noting that this agency is one of the very few local planning bodies across the two cities (considered for this research) that has independently initiated such reforms.

IMPLICATIONS FOR THEORY AND PRACTICE

Evidence from the cases of Dhaka and Kolkata shows that both cities lack comprehensive, explicit climate-adaptation plans. In the absence of such plans, given the critical climatic vulnerabilities of South Asian mega-cities, the overall research question that guides this dissertation becomes especially pertinent: *In the face of existing resource constraints, what planning approaches have most effectively enabled these cities to "adapt" to risks related to climate change?*

This study shows that, although the two cities do not manage climate risks through dedicated adaptation, they are planning and implementing scores of projects designed to increase overall development. Though not intended exclusively as adaptation measures, many of these measures nonetheless do increase the overall resilience and coping capacities of city dwellers. These projects therefore by definition contain some adaptive components and thus merit further investigation. Analysis of the outcomes of these developmental efforts on the water sector reveals that the three illustrative projects do show a demonstrably higher capacity for directly or indirectly addressing the water-related impacts of climate change.

Moreover, these measures are generally rooted within broader socio-economic development projects, which usually enjoy strong financial support and political consensus, as was the case in Dhaka's Integrated Flood Protection Project, which not only helped with riverine flood protection but also helped to solve some of the existing persistent problems of drainage congestion. In addition, the comparatively limited scope of these efforts allows for greater operational control and, more compelling, can exploit the advantages of incremental implementation.[32] This can be seen in the East

[32] Beach and Connolly identify the criteria for successful incremental implementation: "The elements of the problem are interdependent...Iterative solutions are possible...Corrections

Kolkata Wetlands Project, where the different components of the projects were sequenced to maximize the benefits. For example after the main sewer trunks were de-silted and became operational it was evident that the pipes could be extended to connect to the sewage ponds for further treatment. Finally, the narrow focus of such contingent adaptations enables more effective oversight from governmental and international partners, resulting in greater accountability, as was the case again with the EKWSP.

In addition, these projects also share three fundamental characteristics that correlate well with successful adaptation outcomes in resource-constrained environments:

First, city-level agencies have planned these projects from the onset with certain specific climate-adaptation criteria in mind; the subsequent successes were thus neither merely incidental nor serendipitous. Second, in shaping these initiatives, the local organizations pursued several climate-adaptation goals in addition to targeting economic development. For example in the DIFPP, flood adaptation was considered a primary adaptive component, while in EKWMP concerns of water-logging, drainage, and flood water retention were also concerns integrated at the project planning stage. Third, and equally important to the successful and timely implementation of these projects, was that the city-level authorities were able to overcome three central barriers—*resource limitations*, *institutional barriers*, and *implementation hurdles*–that are pervasive throughout the cities of South Asia.

The options afforded by these projects nevertheless cannot be considered "sufficient" for long-term adaptation, given both the absence of extensive adaptation plans and the numerous, critical barriers to planning and implementation. Despite such deficiencies, such approaches are "necessary" and do present practical and viable opportunities for planners to effect substantial climate adaptation in resource-constrained environments. As Susskind (2010) rightly asserts, "Adaption plans will [have to] be much more incremental. Given the enormous uncertainties involved, city...planners will not be able to work backwards from definitive long-range forecasts or a set of carefully defined planning goals and policies." Therefore, in local environments where targeted adaptation planning is almost non-existent,

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are possible and there is a range of possible solutions...The sequence of solution steps is flexible and robust in the face of interruptions" (2005: 152-153). The contingent adaptation projects discussed here generally meet these criteria for efficacious incremental implementation (Beach, L. R. and Connolly, T., 2005).

such *contingent adaptations* gain stronger relevance. Moreover, these "adaptation" approaches may enable local actors to overcome the complex array of obstacles to effective climate-risk planning more easily than they could when trying to implement a stand-alone adaptation plan. The challenge remains, however, in identifying, designing, and implementing a substantially larger number of such projects, as only the cumulative effects of many *contingent* measures bring as much adaptive benefit as does dedicated adaptation planning. Regardless of the *number* of measures, *contingent adaptation* approaches do reduce climate risks while helping to increasingly make adaptation an integral component of planning agendas throughout the Global South, thereby assuming a strong relevance in both practice and theory.

> *Such an approach, which I term "**contingent adaptation,**" can then be defined as a planning approach that articulates adaptive criteria at its inception, fulfills specific long-term adaptation goals, and in the interim serves as a viable substitute for dedicated adaptation planning; the precise elements of this approach are* <u>*contingent*</u> *upon the developmental goal* (e.g., augmentation of the urban water supply) in question.

The examples analyzed in depth in the previous section, including Dhaka's FAP8 Flood Action Plan, the TurnAround Program for Dhaka, and the East Kolkata Wetlands Project, fulfill the criteria for "contingent adaptation".

In addition, while adaptation in actual practice cannot often be clearly differentiated from the host of ongoing developmental activities, an examination of the empirical evidence of the processes from Dhaka and Kolkata does provide some key propositions for how similar adaptations can be successful in overcoming these challenges. For such contingent adaptations to be successful, planners need specific strategies to surmount the three typical obstacles outlined above: resource constraints, institutional barriers and implementation hurdles. Table 5.1 (at the end of the chapter) summarizes the overall findings from the three project case studies that can guide such specific strategies. The resulting theoretical propositions that are supported by the data are as follows:

- Internally initiated organizational actions can help reduce local resource deficits without the need to resort to external aid.
- Aligning interests or enabling collaborative partnerships with external organizations can help local agencies generate external funds.
- Modification of existing organizational structures can reduce institutional

barriers.

- Stronger political commitment and higher project visibility increases likelihood of implementation.
- The likelihood of adoption of adaptive projects increases when integrated into or coupled with existing planning agendas.

Overcoming Resource Constraints

Resource limitations, especially funding constraints, can severely impair all planning initiatives, not only *contingent adaptation* measures. As seen in the cases described above, however, in contingent adaptation, resource deficits can be addressed in a wider variety of ways; moreover, revenue and external support may be more easily augmented, particularly where the various institutional and political actors collaborate effectively and the projects have high visibility. Several characteristics of these contingent adaptations enable greater resource flexibility.

Inductive analysis of the cases shows that both external and internal factors substantially influence resource availability in local organizations. To lessen resource constraints, organizations can generally increase operational efficiencies (thus reducing costs) and/or enhance revenues; two key internal approaches that surfaced in this research. First, an institutional restructuring, designed to *identify redundancies in order to streamline functions*—thereby increasing operational efficiency—can result in considerably lower outlays. This is evident in the case of DWASA, where such measures increased the operational efficiency from 0.79 to 0.9 in less than two years, reducing administrative and operational expenses significantly. Moreover, *streamlining organizational functions* can also facilitate revenue generation. Examples include revising water tariffs to reflect escalating operating costs and improved water supply (as DWASA was able to do), or focusing on improving existing funding channels and making revenue collection procedures more efficient (as occurred with KEIP's Project Accounting System). Such actions can help local organizations tap into already existing resources without requiring substantial reorganization to realize cost savings.

Another internal mechanism for surmounting barriers is found in 'embeddedness'. Local agencies can identify opportunities in which adaptation planning can in effect be coupled with existing development ventures, obviating the need for independent, costly infrastructure projects. Urban wetland management and city drainage represent prime opportunities for such synergistic planning. As detailed above in the discussion of the management of the East Kolkata Wetland Systems (EKWS), urban wetlands have the capacity to work as natural drainage systems. Additionally, through proper utilization, wetlands can also reduce the need for the construction of additional pumping stations and treatment plants, serving as waste-water purifiers and floodwater retention areas. Another added benefit, as seen in the case of Kolkata, is the capacity of the urban wetlands to increase urban agriculture and aquaculture, which in turn can address issues of food security and augment the local economy. This alignment of developmental and climate-risk goals is central to the concept of contingent adaptation.

Apart from these two primary ways in which resource constraints can be overcome internally, direct resources are also available through external institutions for many of the developmental initiatives that fall under the concept of contingent adaptation. In both Kolkata and Dhaka, international donor organizations, such as the World Bank, ADB, JICA, and DINADA, are actively engaged on local levels and can make extensive financial aid available for large infrastructure improvements and institutional enhancements. In addition, the national governments of both India (through its JNNURM activities) and Bangladesh through a series of specific climate-adaptation funds, distribute resources—including financial, human, and physical capital—for climate-related projects. However, it is only where local agencies have made efforts to enhance their own institutional capabilities and operations that these partnerships have ultimately proven fruitful. For example, the FAP8B in Dhaka was successful not only because the project received considerable support from international donors and the national government, but also because the local agencies involved in implementing the Plan, most notably, RAJUK and the DCC, established effective organizational structures and championed the initiatives. Another such example of a complementary partnership can be seen in the case of KEIP, where the agency adopted numerous operational and managerial innovations in order to utilize the ADB funds effectively and to comply with the latter's conditions and operating procedures (ADB, 2010).

Overcoming Institutional Barriers

"Taking or designing adaptation actions is facilitated or constrained by existing institutions, which have their own logic, history and transaction costs" (Pelling, 2011: 112). In unpacking the complexities surrounding these adaptive actions, institutional modification is seen as a primary catalyst in facilitating contingent adaptation. As evidenced in Kolkata and Dhaka, the impetus for such organizational reform can come either from within or from external stakeholders. In the context of South Asian mega-cities, institutional barriers take many forms: lack of capacity; insufficient accountability; political interference; inability or unwillingness to restructure or innovate; and poor inter- or intra-institutional coordination. The nature of institutional design in both Kolkata and Dhaka offers insights of opportunities for overcoming such institutional barriers, however.

Some of the key reasons why theorists have traditionally favored locally directed efforts over centralized, hierarchical, top-down development strategies include engendering competition, limiting redundancy, enhancing accountability to clients, furthering local adaptation, and encouraging simplicity in processes. Such decentralized approaches, however, have often actually been counterproductive in these cities. In fact, in resource-constrained local environments, "local" approaches have not generally become more responsive to local needs, made local institutions more viable, enabled adaptation projects to be sustained after external support is exhausted, or promoted greater efficiency or effectiveness. This failure stems not from inherent limitations of decentralization, but from the incomplete ways in which agencies in Kolkata and Dhaka are generally empowered. In fact, local agencies under these conditions of *partial* decentralization—where institutions are expected to perform autonomously, yet without adequate decision making authority—have experienced consistent deficits in resources, capabilities, human resources, and political support.

However, the successful examples of DWASA's Turnaround Program, KEIP's management of the EKWS and Dhaka's FAP8B (in which involvement of RAJUK and the DCC played leading roles) all point to some key modifiers for institutional design, upon which organizations within these constrained environments can flourish. These local organizations have indeed managed to avoid the pitfalls of ineffective decentralization while simultaneously improving performance, augmenting accountability, and engendering an autonomous identity for decision-making. To circumvent the barriers, these local institutions operate within hybrid organizational structures, in which they borrow key elements of top-down hierarchical frameworks and enjoy some of the advantages (including agility, responsiveness, and participation) of local approaches. Both KEIP and DWASA have in effect created insular organizational structures; KEIP, for instance, though it is staffed with representatives from local agencies, has established an independent identity and separate head.[33] In addition, although KEIP remains accountable in

[33] Although senior KMC officials have attempted several times to bring KEIP under closer KMC control, intervention from the State government and external funders, particularly the

theory to the state government, the budgetary autonomy provided by ADB funding allows the agency in effect to answer only to its clients and ADB.

Likewise, Dhaka WASA's decision-making processes have gained a significant degree of independence from political interference, and the agency has taken on a more influential role, principally because it benefits from significant financial autonomy and a corporate-type structure. This considerable fiscal independence also enables both KEIP and DWASA to set their own agendas, chart revenue streams, allocate personnel, and utilize outside assistance to address capacity gaps. As stand-alone bodies with clearly delineated functions, both DWASA and KEIP have also become increasingly accountable to the local residents, thereby improving overall performance. Another important outcome of this internal and top-down—and thus relatively exclusive structure—is clarity in an organization's functions and planning agendas. Such an administrative framework removes ambiguity in terms of an institution's specific responsibilities and affords an agility to reorganize and make decisions based on the dynamic circumstances. The ability to plan and operate autonomously also curtails the need for often-counterproductive, negotiated compromises with other agencies, easing the barriers to inter- and intra-agency coordination.

Where complete institutional restructuring is not possible, as was the case in coordinating and implementing the Dhaka's Flood Action Plan, other policies can also bring similar advantages. In the case of the FAP8B, defining plans clearly, allocating budgets from the onset (at the project planning stage), demarcating roles and responsibilities, and, most important, creating a hierarchy of authority (through independent units) to supervise the work and ensure accountability for the project, were key to its success. In addition, though no new agencies were formed, autonomous committees, such as the Steering Committee and the Project Coordination Unit, were created exclusively to carry out the FAP8B. These committees were comprised of representatives from all participating agencies and ministries.

For local agencies to be successful in their adaptation efforts, political support, particularly from the national government, is critical for their success. In the case of Bangladesh, local agencies in Dhaka have been able to accomplish more, than those in Kolkata, partly because of the shift of

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ADB, has preserved KEIP's independence (*The Statesman*, 2012b). KEIP's autonomy—which enables the organization to collaborate effectively with other agencies, different levels of government, and international partners—has been crucial to its success in addressing wastewater hazards.

government policy towards one that affirms the importance of climate adaptation. This shift translates into political support at the local level for such efforts. The FAP8B stands out as a key venture that illustrates this correlation. In addition, the high national and international visibility of such projects also creates an impetus within the local agencies to perform better, especially insofar as the likelihood of donor support thereby increases. This is demonstrated clearly in the case of DWASA. The organization in anticipation of additional ADB and DANIDA funds, made performance agreements with the national government, substantially overhauled the agency, participated in the international water agency community's activities, which won them the "Performer of the Year" award; all of these factors contributed to its proactive institutional modification.[34] In the case of KEIP, such accountability and institutional enhancement was externally motivated, but nonetheless had exceptional results. The substantial multi-year financial aid from the ADB was the primary incentive for KEIP to be formed and was an important factor in the organization's consequent institutional innovations. The formation of project management units, regular accountability procedures, and operating and implementation guidelines were all conditions of the ADB contract. However, both KEIP's digital accounting system to enhance business processes and its collaborative consultations to augment technical capacities were innovations created internally as part of the momentum generated by the initial ADB guidelines. Of these internal efforts, the modernization of operating processes and the hiring of external consultants to bridge the capacity gap for specific projects provide viable models for resource-constrained local agencies to follow in addressing key barriers, such as capacity gaps, and in increasing transparency. In the cases of both DWASA and KEIP, forward-thinking institutional champions instituted meaningful and fruitful reforms that achieved considerable success in addressing climate-adaptation needs.[35]

Overcoming Implementation Hurdles:

Several factors increase the likelihood of implementing contingent adaptations. Some criteria, such as high national and international visibility of the projects, anticipation of state, national, or international funds, and support

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[34] Interviews with several officials of DWASA in June 2012 provide confirmation of this analysis.

[35] DWASA's managing director, Taqsem A. Khan, has been the agency's champion, while KEIP's, top officer, Susit Biswas, has been a strong leader, according to most of the interview respondents who spoke on this matter.

from external donor communities, play strong roles not only in increasing the likelihood of such projects being implemented, but also in the possibility of their overcoming institutional constraints and resource deficits, while generating successful outcomes.[36]

The positive examples of urban flood management and water supply management in Dhaka and of wetland management in Kolkata suggest that extant infrastructure projects that lend themselves easily to concomitant management of climate-induced risks are more likely to receive higher priority for authorization, funding, and implementation. For example, flooding resulting from drainage congestion has been an ongoing and serious problem for Kolkata. To make matters worse, this type of flooding has increased in magnitude and intensity in the past decade or so because of progressively frequent and intensified local rainfall patterns, likely at least partly the result of climate change. At the same time, the city's sewer and storm-drainage systems, which were designed as combined structures, need to be augmented and refurbished, not only because they have reached their capacity, but also because a majority of the lines are in various states of disrepair. Since the effective management of the urban wetlands in Kolkata offers an avenue for combining efforts of a number of city public agencies (e.g., municipal planning bodies, organizations responsible for the water and sewer sectors, and environmental and flood-control bodies) to solve a number of problems simultaneously, many of these agencies have pooled resources and concentrated their planning initiatives to address such issues collectively (as illustrated in the case of KEIP). DWASA's Turnaround Program also specifically addresses issues of water scarcity and quality—concerns that lend themselves naturally to adaptation goals—while also increasing overall developmental standards of the city of Dhaka.

Lastly, the prior experience and relevant expertise of the agencies involved in projects play a crucial role in the likelihood and level of implementation of adaptation measures within "regular" planning initiatives. In the case of FAP8B, BWDB, the agency charged with coordinating and implementing Phase I of the project, enjoyed both of these attributes. In the case of KEIP though local agency representatives lacked the required knowledge of and experience in adaptive wetlands management, they nonetheless overcame

[36] As discussed previously in this chapter, in the case of flood management through the FAP8, high visibility of the flood impacts and support from the national government and international donor agencies played an important role in the implementation of the first phase of the project.

these deficits by hiring external consultants for the duration of the project; such consultants became an integral part of the organizational structure.

The analysis of the cases thus supports the following conclusions regarding overcoming barriers to implementation:

- Impacts of climate risks that are highly visible create higher visibility of the issues in both national and international areas. Higher visibility may command more attention and support for these issues, wherein the likelihood of adaptation measures concerned with these impacts increases.

- Climate-related issues are often given priority and contingent adaptation projects are more likely to be implemented when they can be coupled with existing planning initiatives or integrated into broader infrastructure projects.

- Projects that collectively encompass multiple objectives, such as augmenting urban livelihoods and reducing the need for additional infrastructure, while simultaneously addressing planning and implementation needs, are more likely to catalyze inter- institutional and stakeholder support, which in turn facilitates their successful implementation.

- Contingent adaptations are more likely to be implemented where the participating agencies have the expertise and prior experience in similar efforts.

TABLE 5.1: Pathways for Overcoming Key Barriers to Adaptation Planning

RESOURCE LIMITATIONS

FINDINGS	SUPPORTING DATA
Internally initiated organizational actions can help reduce local resource deficits without the need to resort to external aid.	**Increased operational efficiency** ▪ Reduced non-revenue water (NRW, unmetered water and transmission losses) through infrastructure improvements (TurnAround Program) ▪ Eliminated operational redundancies for overlapping duties (e.g., in management of sewer and drainage systems), thereby reducing overall personnel needs (TurnAround Program) ▪ Streamlined functions through new technologies (e.g., GIS-enabled archiving and decision-making systems, digital accounting), decreasing total operational costs (TurnAround Program and EKWSMP) **Consolidated existing revenue sources** ▪ Periodically revised tariffs to reflect higher operating costs and service improvements (TurnAround Program) ▪ Expanded service areas to broaden income streams (TurnAround Program) ▪ Reorganized and consolidated revenue territories to enhance efficiency in collections (TurnAround Program) ▪ Outsourced revenue collection functions in all service areas to capture previously lost revenues (TurnAround Program) ▪ Established timely billing, payment and recovery procedures via web- or SMS-enabled interfaces (TurnAround Program) and digital project

accounting systems (EKWSMP)

Coupled existing planning initiatives to address multiple needs

- Incorporated drainage and greywater-treatment functions into wetland preservation efforts, reducing the need for additional infrastructure (e.g., treatment plants and pumping stations) while alleviating water-logging in adjacent areas (EKWSMP)

- Provided fishponds and reserved farming areas to encourage aquaculture and food production to supplement local economies (EKWSMP)

- Utilized external expertise and resources to jointly plan, implement, and finance augmentation and repair projects for local drainage systems in order to decrease water-logging, which enabled DWASA and DCC to address other needs (DIFPP)

Aligning interests or enabling collaborative partnerships with external organizations can help generate external funds

- Created a largely autonomous sub-agency to comply with ADB loan conditions, which ensured external funding for current and future projects (KEIP)

- Partnered with national agencies to carry out development and adaptation efforts while ensuring local interests (DWASA, DCC, RAJUK)

- Identified likely international and national donors, including the ADB and DANIDA, to generate external funds for ongoing developmental and adaptation projects in the water sector (DWASA)

Enhanced organizational performance and accountability

- Made organizational and operational modifications to adhere to donor-agency guidelines (KEIP)
- Increased accountability and transparency due to external pressures from donor agencies (KEIP)
- Leveraged strong organizational leadership to increase engagement across various levels of the organization (DWASA)
- Voluntarily participated in national and international monitoring programs to ensure compliance (DWASA)

Modification of existing organizational structures can reduce institutional barriers

- Established complaint cells and real-time service status reports to increase accountability to customers (DWASA)
- Furthered administrative independence through creation of an autonomous (DWASA) or insular agency (KEIP):
  - Allowed the local agencies the freedom to set tangible organizational achievement targets (such as greater operational efficiencies) (DWASA)
  - Enhanced agility in decision-making (KEIP and DWASA)
  - Established direct accountability to residents, mediated by local NGOs (KEIP) or through allocating dedicated company service representatives (DWASA)
- Aligned projects with national climate agendas to obtain greater political support (DIFPP)
- Ensured accountability through direct reporting to national agencies (DIFPP)

Significantly improved co-ordination and implementation of projects

- Clearly demarcated responsibilities within organizations and among other local/state/national agencies at project inception (DIFPP)
- Included representatives from key local and national agencies and delegated explicit responsibilities to specific organizations (DIFPP)
- Established precise reporting structures and/or hierarchies and created distinct management and technical units (KEIP and DIFPP)
- Established clear plans, final objectives, and implementation guidelines at project inception (KEIP, DWASA and DIFPP)
- Collaborated with local NGOs to increase public stakeholder support for wetland management (KEIP)

Addressed technical- and human-resource capacity gaps

- Hired wetland experts as consultants from project conception to completion, facilitating consistent expert input throughout the project life cycle (KEIP)
- Outsourced peripheral functions, such as billing procedures and revenue collection, to address human resource gaps (DWASA)
- Collaborated with national agencies that possessed prior experience in certain technical facets of the project (e.g., BWDB's relevant proficiency in building flood embankments) to bridge the technical gaps of the local agencies in this area (DIFPP)
- Implemented employee training programs and created new operation manuals to reflect improved practices (KEIP, DWASA)

Reduced political interference

- Created autonomous (DWASA) or insular sub-agencies (KEIP) to achieve functional independence from local politicians and special-interest groups

- Secured relative financial autonomy through external donor agencies (KEIP)

INCREASING LIKELIHOOD OF ADOPTION

The likelihood of adoption of adaptive projects increases when integrated into or coupled with existing planning agendas

- Fulfilled local developmental needs through the construction and repair of primary roads, which secured support from local agencies while ensuring access to transportation networks during floods—the larger adaptation goal for the project (DIFPP)

- Gained strong support from multiple private and public stakeholders by addressing several concerns simultaneously (EKWMSP, KEIP). These "integrated" initiatives included:
  - Constructing storm and sewer systems to increase network capacities, thereby reducing overflows and contamination;
  - Preserving environmentally sensitive locations, such as flood zones and wetlands; supporting local aquaculture and agriculture;
  - Increasing capacities for storm-water and drainage systems to address rising population concentrations and water-logging during periods of intense precipitation;
  - Using wetlands for flood-water retention and drainage, thereby making additional pumping stations and water treatment plants unnecessary

- Addressed primary developmental concerns and adaptive needs by:
  - Increasing water availability and quality (The TurnAround Program)
  - Drawing principally upon surface-water sources in planning new water supply infrastructure, which helped to reduce both groundwater

		depletion and levels of water contamination
Stronger political commitment and higher project visibility increases likelihood of implementation	▪	Lobbied for political support by participating in national and international water programs to ensure project buy-in (DWASA)
	▪	Increased project visibility by conducting best-practices workshops for other water agencies around Bangladesh and by educating the public through advertising on billboards and in brochures (DWASA) -
	▪	Actively participated in national and international climate-change negotiation venues to broaden their visibility beyond the local region and thus to avail of external funding and technical support opportunities (DIFPP)

6

CLIMATE ADAPTATION IN SOUTH ASIAN MEGA-CITIES: MAKING A CASE FOR "CONTINGENT" APPROACHES

It is not the strongest nor the most intelligent of the species that survive; it is the one most adaptable to change.

-- Charles Darwin, *On the Origin of Species*

WHY SOUTH ASIAN MEGA-CITIES?

Currently, five of Asia's eleven mega-cities are located in the South Asian region[1] and are at substantial risk from the effects of global warming. Various studies indicate that a number of other densely populated, though smaller, cities,[2] particularly coastal ones, are also increasingly imperiled by climatic change. The graveness of this situation is further aggravated by the fact that these cities moreover rank very low in their adaptive capacities (WWF, 2009). Predictions based on climatic modeling and the conspicuous changes in weather patterns provide substantial evidence that these cities are not only currently experiencing the adverse effects of climate change, but will also face critical urban risks—increasingly aggravated by climatic effects over time. Unfortunately, however, despite these vulnerabilities, substantive action on climate adaptation in this region currently remains marginal at best (see, for example, Miah et al., 2010; Inauen et al., 2013; D'souza and Nagendra, 2011; Davis, 2004; Anik et al., 2012; Dewan et al., 2012; Braun and Aßheuer, 2011).

The nature of these high-density urban spaces, however, can also facilitate successful adaptation measures through efficiencies of scale, as such projects may directly affect thousands. Moreover, major cities exert a much broader influence on surrounding areas, engendering wider

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[1] In addition to Kolkata and Dhaka, Mumbai, Delhi, and Karachi all rate as mega-cities; each has a population (metropolitan area) of at least fourteen million (World Bank, 2012).

[2] Recent scholarship on future vulnerability to coastal inundation identifies major South and East Asian cities as the globe's areas most at risk for loss of human life and property. See Nicholls et al. (2008) for a comprehensive study of 136 port cities worldwide, as well as WWF (2009).

acceptance and political will for such adaptive efforts. Climate-adaptation action in major and mega-cities is especially important because such cities have dramatic impacts upon the social, economic and political makeup of the broader region (Olorunfemi, 2009). Moreover, these large cities have long exercised broad yet subtle hegemony—especially in economic and political terms—over surrounding regions (Chase-Dunn and Manning, 2002). As much as these urban centers depend on the various resources, especially agricultural production and labor, of their respective regions, these cities thus also enjoy large spheres of political, economic, social, and cultural influence (Kraas, 2003), which extend far beyond the immediate areas. Such hegemonic relations, which arose historically largely through social and cultural "pull" forces, now act primarily through economic ones; as the regional centers for finance and labor, Asian mega-cities in particular shape their surrounding communities in profound and far-reaching ways (Hutton, 2012). Since effective adaptation strategies in mega-cities have a strong bearing on policy for the region and beyond, mega-cities therefore represent a logical starting point for ambitious vulnerability reduction and resilience-building actions.

Several researchers have outlined the factors that make cities the essential focal points (or "development hotspots") for climate-adaptation action (e.g., Penalba, Elazegui, Pulhin, and Cruz, 2012; Dosch and Porsche, 2011). Simply put, the concentration of people, resources, and structures in large cities both creates a far higher need for risk reduction and enables much greater "return on investment" for such efforts. Coastal cities in particular represent the most crucial sites for building adaptive capacity (McGranahan, Balk, and Anderson, 2007). Especially when adaptation measures are integrated with broader development, as this work argues should be the case, the scope of possible actions, and thus the opportunity to utilize coastal mega-cities as "proving grounds" for projects that can build adaptive capacity, is infinitely greater in such metropolises. My research suggests that the creative space in which mega-cities can pursue the parallel aims of enhancing the resilience and lessening the vulnerability of their residents across the socioeconomic spectrum is quite broad.

While mega-cities serve as development hotspots, enjoying more numerous options for ambitious adaptation measures by virtue of their political and economic strength and concentrated populations and infrastructure, these cities also create conditions for increased social inequality, political instability, environmental degradation, and health risks[3] (Birkmann, 2011). In mega-cities of the developing world, particularly in South Asia, the rapid rate of expansion almost universally outpaces the development of infrastructure and provision of basic services. This situation manifests itself in issues such as scarcity of water supply, lack of emergency response systems, and insufficient drainage- and sewage-system carrying capacities. Moreover, the rapid pace of development often results in a loss of governability (Birkmann, 2011) and in capture by informal players, such as developers. Formal actors, especially city-level agencies, thus cannot effectively guide orderly development efforts, as the profits that come from unregulated construction lead PLDCs to flout laws that remain unenforced (Das, 2010).

Broader significance of Kolkata and Dhaka

The two mega-cities on which this research focuses, Kolkata and Dhaka, are ideal centers for research by virtue of their risk levels and potential for effective climate action. As the political, economic, and cultural centers of their respective areas,[4] the two cities are central to the identity of their respective regions. Moreover, given the hegemonic relations these cites have over their surrounding areas, effective adaptive actions in Kolkata and Dhaka could exert a positive influence beyond their own boundaries. At the same time, reducing the vulnerability of urban populations can have a significant ripple effect on surrounding communities, as the shared economic ties will ensure that "adaptation and risk management policies (e.g., land-use planning, flood defenses, subsidence control) can yield very large benefits" for the broader region, primarily through the protection of assets from climate-related impacts (Hallegatte and Corfee-Morlot, 2011: 6). More specifically, for example, by enabling more robust river outflows, urban de-siltation would greatly improve up- and down-stream aquaculture and agriculture while ameliorating flooding risks (Ahmed, Rahman, and Stuart, 2013). The environmental effects of adaptive actions

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[3] The high density and extreme international mobility of these cities' populations also pose other key problems. For example, in the sector of public health, diseases can be spread very easily and quickly if they remain unmonitored or uncontained. Glouberman et al. (2006), for instance, detail the role of highly transitory, crowded metropolitan areas in furthering the global transmission of the SARS epidemic of 2002-2003.

[4] Kolkata is the only major city in the Indian State of West Bengal and has served as the cultural capital of India since the 19^{th} century and represents about 17% of West Bengal's population; Dhaka, as the capital of Bangladesh, accounts for 10% of the entire country's population (World Bank, 2012).

in coastal mega-cities may thus bring substantial ancillary benefits for the region as a whole.

Vulnerabilities

The risk assessments prepared for Kolkata and Dhaka (see chapter 2) show that both cities face a wide range of climatic risks, the most acute of which have to do with potable water.. These risks will be aggravated by temperature increases, periods of intense rainfall, sea-level rise, salinity intrusion and land subsidence. Moreover, storm surges, cyclones, and urban floods of increasing frequency and intensity are already having devastating effects. Known as the "flood of the century", the 1998 floods in Bangladesh, for example, inundated about sixty percent of the country for a period of over three months, during which parts of Dhaka remained submerged under six feet of water (Del Ninno, Dorosh, Smith, & Roy, 2001). The scale of destruction was unprecedented, totaling $2.8 billion; the flooding badly damaged over half a million homes and devastated the country's infrastructure. Of course Dhaka, by far the nation's largest and most densely populated city, bore a huge portion of these losses. With over 39,000 square miles under water, the floods of 1998 ultimately claimed over 1000 lives and about 30 million people were left homeless (NAPA, 2005; Cullen, 2010: 198)[5].

Such extreme flooding events call attention to the ways in which social, economic, and political (non-climatic) vulnerabilities increase a population's risk.. They are particularly evident in Kolkata and Dhaka, where rapid population growth and high density, along with the cities' widespread poverty, reduce the effective resilience of the cities. Moreover, the accompanying sub-standard housing in the low-lying, densely packed, unhygienic slums significantly increases the population's vulnerability to disease and epidemics. The vulnerabilities arising from the high densities and increasing population are not limited to poor sections of the city. Both Kolkata and Dhaka are being "developed" at an exponential rate[6], and such development has had serious environmental impacts,

[5] Haque et al. argue that "improved defensive measures, including early warning systems, cyclone shelters, evacuation plans, coastal embankments, reforestation schemes and increased awareness and communication" reduced the death toll from the 2007 cyclone (less than 5000) dramatically, compared with the 1970 cyclone in Bangladesh, with total fatalities estimated at 500,000 (2012: 150).

[6] Both cities are currently facing chronic housing shortages, making the need for construction and development another contributing factor to climate risk (Reuters, 2006).

ranging from the destruction of the urban wetlands, to increased runoffs and decreased ground water recharge zones. Groundwater sources are not only depleting and increasingly becoming contaminated, but the cities are losing their "green spaces" and natural drainage systems. These environmental resources would otherwise have served to reduce "urban heat-island" effects (by reflecting a far higher proportion of heat than do buildings or asphalt) and absorbed floodwater drainage. The statistics on the loss of green spaces in Kolkata, for example, show that green spaces represent only 3% of the city, versus over 20% in Delhi (*Business Standard*, 2011), with parks, open spaces, and agriculture taken together accounting for less than 14% of Dhaka.

Systemic issues

> "Non-climate stresses can increase vulnerability to climate change by reducing resilience and can also reduce adaptive capacity. ... Adaptation measures are seldom undertaken in response to climate change alone but can be integrated within, for example, water resource management, coastal defense and risk reduction strategies" (IPCC 2007: 19)

Weak drainage, water and sewer infrastructure add further to the risks facing Kolkata and Dhaka. Already threatened by depletion of ground water, salinity intrusion and destruction and contamination during floods and storms, the lack of a robust infrastructure can impair the quality and availability of fresh water supplies. In fact, Kolkata and Dhaka's problems arise from having "too much and too little water". Though both cities have potentially ample sources of fresh water from adjoining rivers; ironically, though, this water is largely unusable because of water-pollution levels. Moreover, the lack of adequate surface-water treatment plants translates to an overreliance on groundwater supplies, principally through tube wells. Groundwater is not only fast depleting but is also threatened by saline and wastewater/sewage contamination; the latter is a direct result of deteriorating and inadequate infrastructure. In addition, the cities' utility-related water infrastructure services only relatively small portions of the city, further exacerbating water scarcity (Hackenbroch and Hossain, 2012).

Drainage congestion, which is a huge problem for both cities, can be attributed directly to the combined consequences of both climatic change (in the form of intense periods of precipitation) and inadequate infrastructure. Almost every interview I conducted with officials in Kolkata and Dhaka on the subject, suggested that drainage congestion is one of the biggest causes of urban flooding. Though the cities cannot significantly change regional and global rainfall trends, local drainage infrastructure improvements as well as further regulation of development[7] and land use could certainly alleviate regular urban flooding (Bose, 2007).

Climatic and non-climatic risk factors not only work in concert, but often also reinforce each another. Higher inundation levels, for example, lead to greater degrees of siltation. This worsens drainage congestion. All three reduce the availability of potable surface water, increasing reliance on groundwater, thereby worsening salinity intrusion and accelerating land subsidence. This downward spiral ought to provide an impetus for climate-adaptation.

Indeed, it ought to be possible to reduce vulnerability and enhance resilience by taking advantage of "low-hanging fruit", that is, projects that are cost-effective and provide a range of benefits across several fields. The climate models developed by Dasgupta et al., for example, found that "de-silting of the main sewers [in Kolkata] would reduce vulnerable population estimates by at least 5%" (2013: 747). This would produce collateral effects, including diminished water-logging, river levels, and surface-water contamination (reducing vulnerability) and improved fishing and farming in surrounding areas (building resilience). Likewise, in greater Dhaka, targeted reclamation of wetlands or mangroves, for instance, would provide insulation against cyclonic activity and storm surges, reduce urban heat-island effects, and channel floodwater runoff (reducing vulnerability), while also promoting surface water recharge, raising yields from aquaculture and agriculture, enhancing biodiversity,

[7] To get a sense of vast scale of building activity, in Kolkata alone, just in a one-year period (2005-2006), KMC sanctioned 3000 building permits for the construction of medium and high-rise buildings in the city, an astonishing figure that does not even account for the ongoing illegal development (KMC, 2006). Moreover, the designs of the recently constructed buildings show that all the buildings use the mandated open spaces within their plot lines to create paved areas for vehicular and pedestrian circulation. Thus the surface run-off areas have increased by 100%, exponentially increasing the sewer and drainage load for the city and further contributing to drainage congestion (Bose, 2007).

and increasing freshwater availability (building resilience) (Erwin, 2009). The problems outlined in chapter 4, namely extreme growth and poor institutional effectiveness, have to date prevented Dhaka from utilizing its extensive network of wetlands to reduce vulnerability to the effects of climate change.

Geography and Topography

As I indicated in chapter 2, Kolkata and Dhaka have problematic geographies—typified by their locations in the low-lying coastal floodplains of the Indo-Gangetic plains–further adding to their climatic susceptibilities (e.g. sea-level rise, coastal storms, salinity intrusion) and of course to the overall risks facing their populations. Moreover, the cities' topographies make them vulnerable in other ways as well. Dhaka is surrounded by four major rivers, all of which are prone to periodic riverine flooding, whereas Kolkata lies on the banks of river Hooghly, where similar flooding is a frequent occurrence. In cities facing land-subsidence aggravated by overdrawing of ground water, the clayey soils with low compressive strengths, particularly along the numerous low-lying wetland areas, creates an unstable base for the dense development that characterizes both cities. Construction in these areas increases the prospect of foundational collapse. Such building collapses have become frequent in Dhaka. During the time that I was in the city in June of 2010, just a single building collapse resulted in 23 deaths and even more injuries. Such collapses, including the ones in 2006 and 2005 which claimed over 110 lives and left over 200 injured, were largely attributed to foundation subsidence and illegal construction in fragile areas of Dhaka (BBC, 2010). Kolkata has also witnessed some building collapses; most recently five people were injured in 2011 (*Hindustan Times*, 2011). Though such collapses have not yet been linked definitively to weak soil-bearing capacity, land subsidence aggravated by withdrawal of ground water, which is certainly occurring in Kolkata, is likely to create differential settlement in foundations, which will likely contribute to building collapses in the future (Bhattacharya and Kumar, 2012).

Institutional factors

My own research, corroborated by the work of other scholars in the field, suggests that ineffective governance, institutional constraints, and limited resources that characterize much of South Asia, (Wunsch, 1991; Birkmann, Garschagen, Kraas, & Quang, 2010) hinder the ability of city-level planners to address climate change, even though the enormous number of people at risk makes such action increasingly necessary. Birkmann, Garschagen, Kraas, and Quang (2010), in reviewing the literature on adaptation in urban areas, including mega-cities around the world, make a compelling case for the "further advancement of urban adaptation strategies as a key imperative" (Hansjurgens 2007; Romero-Lankao 2009; Mitchell 1990). The array of extreme risks that Kolkata and Dhaka face—flooding and water shortages, saltwater intrusion and land subsidence, coastal erosion and species extinctions, among numerous others—require rapid and comprehensive adaptation effort. The fact that they are not underway is cause for grave concern.

The question of how organizations at different levels can best collaborate on these adaptation efforts is a significant concern. While, as detailed earlier, local direction of such efforts brings substantial benefits, city-level agencies also profit greatly from the resources, strategic direction, and accountability that national institutions and non-governmental organizations, such as the ADB and World Bank, can offer (Mahmood, 2009). While city entities possess the local knowledge and stakeholder influence necessary to carry out projects, solitary efforts often falter for lack of guidance and insufficient resources. Moreover, without oversight from external organizations—in terms of "actors, processes, and outcomes"—purely local initiatives are often derailed by corruption (Benner, Reinicke, and Jan, 2004). This research thus argues that while city-level agencies are able to best address local adaptation needs, such planning initiatives can be further strengthened by the support of multi-levels of government, private stakeholders, international agencies, and NGOs.

Adaptation and its discontents

"Hazards are natural, disasters are not". This quote by Cannon (1994) sadly summarizes the situation of Kolkata and Dhaka.

Despite this need for urgent adaptation, city-level agencies are doing almost nothing. Nationally, both in India and Bangladesh, climate action has gained some momentum, but it has yet to be well integrated into the larger planning schemas of the countries. Most adaptation planning that is taking place in these two countries is largely at the behest of NGOs and global organizations such as the International Council for Local

Environmental Initiatives (ICLEI).[8] When I evaluated state-driven measures, as in Bangladesh, I found that such efforts were geared more toward highly vulnerable, rural coastal areas than cities, including Dhaka. While large-scale infrastructure and resilience initiatives in India, particularly those being implemented through the Jawahalal Nehru National Urban Renewal Mission (JNNURM) are noteworthy, climate adaptation is not their primary motivation. Thomas et al. maintain that broader leadership—whether on the state, national, or international plane—is still required for effective building of adaptive capacity: "While the interest in local adaptation planning and policy highlights the relevance of local government for adaptation, its ultimate role with respect to practical implementation of policies and measures is dependent upon other actors within the governance network" (2011: 891). My research confirms this need for higher-level guidance, and support, as the success experienced by KEIP and DWASA (chapter 5) show. While local input into, and design of, adaptation-related projects is crucial to success, city-level agencies in Kolkata and Dhaka generally lack the broad capabilities required to complete such projects. Local partnerships, coupled with national or international resources and accountability, offer the best results. Comprehensive decentralization is thus less preferable to the sharing of authority and responsibility across a multi-level governance structure, as Birkmann, Garschagen, Kraas, and Quang (2010) found in their detailed study of Ho Chi Minh City and Can Tho, Vietnam.

City-level climate adaptation-oriented planning is currently unaddressed particularly by public agencies. Pathways to effective action that are locally initiated and implemented must be found. The long-term sustainability of the large urban areas and mega-cities of South Asia and of the region as a whole depend on it. My research has shown that guidance from municipal officials and local stakeholder support for measures to reduce vulnerability and augment resilience are the keys to successful implementation. In addition, without, financial support, information-sharing, and demands for accountability from higher levels of government or international organizations, city-level organizations are unlikely to maximize the potential gains from adaptive efforts (Garrelts and Lange, 2011).

[8] ICLEI was established in 1990 by a coalition of over 200 local governments. Under its current name, which was formally changed to "ICLEI: Local Governments for Sustainability" in 2003, the organization currently comprises "12 mega-cities, 100 super-cities and urban regions, 450 large cities, 450 small and medium-sized cities and towns in 84 countries dedicated to sustainable development" (ICLEI.org, 2012).

POSSIBLE PATHWAYS TO ADAPTATION

In looking for ways to guide city-level adaptations, (in chapter 3), I focused on several potentially applicable theories that have gained acceptance in adaptation scholarship. Two approaches stand out: "adaptation as development" and the "no-regrets" approach.

Many scholars have explored the concept of "adaptation as development" (including Susskind 2010; Schipper, Cigaran, and Hedger, 2008; Schipper, 2007; Callaway, 2004; Lavell, 2004; Srivastava and Heller, 2003). They have offered competing perspectives on the subject (discussed in detail in chapter 3). The central idea that they share, however, is that managing climate risks through adaptation cannot be separated from the broader efforts of ongoing developmental planning. In fact, the "developmental approach" should be viewed as a way to address both climate adaptation and regular development needs. In the context of urban South Asia, integrating "regular" development adaptation is essential because it means that new approaches to climate adaptation do not have to be conceived separately from "regular" planning efforts. However, the notion that *all* development can address climate adaptation is not helpful.. In South Asia, economics-driven development predominates; this focus receives widespread support from both civil society and local agencies. The city-level priority is economic growth, first and foremost, seen for example in the construction of numerous shopping malls and office parks. Prioritizing adaptation as part of development—as the developmental approach would require—necessitates far reaching buy-in. "Adaptation will have to involve collective action" (Susskind, 2010: 221). Societal commitment thus must come before development opportunities can be filtered through the lens of climate adaptation.

Proponents of the no-regrets approach, thinking along similar lines, maintain that planning authorities should pursue adaptation efforts within the context of on-going development measures. Moreover, in this approach to policymaking, these efforts should simultaneously satisfy multiple goals and stakeholder groups. Moreover, by design, no-regrets initiatives can succeed under a wide range of actual climate scenarios, and thus depend less on the accuracy of current models (Callaway, Kašćelan, and Markovic 2010).] Unlike the developmental approach, though, no-regrets advocates think in terms of resource-constrained environments. For example, in the case of expanding or upgrading water supply infrastructure, in utilizing the no-regrets approach, such infrastructure planning would take broader climate risks into account, but these risks would not fully dictate the nature of the developmental actions required. A second example that illustrates the "no regrets" approach deals with piped water supply. In both Dhaka and Kolkata, as in many other rapidly expanding Asian mega-cities, providing piped water supply to city residents is a primary objective of the urban development agenda. Such infrastructure projects lend themselves easily to a no-regrets approach, since expanding water supply though normal development measures can also further adaptation and resilience in water-stressed cities. In incorporating the no-regrets approach, two distinct benefits can emerge. First, adaptation can be more readily incorporated into the regular developmental agenda, thereby requiring relatively fewer interventions than would separate adaptation measures. Second, and perhaps more important, in the context of developing nations, the resources allocated to "regular" planning projects can simultaneously be used to address climate risks. Thus, planners advocating climate change adaptation, and citizens supporting it, will have no regrets regarding the use of the funds involved whether climate risks worsen or not.

Although this dissertation draws on "no-regrets" in considering adaptation-related planning in the Global South, particularly in the way the approach conceives the utilization of resources within an integrated development-adaptation framework, the numerous, contested interpretations of the theory make it difficult to apply in practice. The theory offers neither specific criteria for deciding among adaptation options, nor guidance on issues of implementation and jurisdiction, two key issues in the cities I studied. In some cases, where projects do have adaptive potential, issues of economic development, infrastructure, or social justice represents the principal policy justifications for projects, while reducing climate-related risk is treated as less important. The no-regrets perspective does not go far enough in ensuring the building of adaptive capacity, often defaulting to the "least common denominator" of climate action. No-regrets approaches may therefore result in policies that simply promote broad-based development containing limited adaptive components (Adler, 2000) or that neglect issues of social justice.

Institutional limitations

Adaptation in Kolkata and Dhaka is just beginning. Apart from financial and technical constraints, a host of institutional barriers limit the scope of action for city-level planning agencies. These barriers are discussed in chapter 4, using illustrative examples, including wetlands management in Dhaka and flood management in Kolkata. Upon analyzing the reasons for the failure of such efforts, several institutional barriers come to light. These include overlapping jurisdictions—a situation that leads to poor coordination—and problems with implementation, overall accountability, uncertainty about specific responsibilities, unclear reporting structures, undue political influence and at times general institutional inertia. All these factors affect the extent to which projects are able to fulfill specific objectives. In such cases, though "no-regrets" offers a *conceptual* understanding of the nature of projects that might be best suited to overcome resource constraints or address adaptation within the larger developmental framework, it provides no further guidance concerning questions of *how* institutions can overcome such barriers to implement such efforts. The likely result is at best partial fulfillment of adaptive goals (Byrne, Young-Doo, Lee, and Kim, 1998). The no-regrets approach thus is often insufficient, taking largely symbolic action in the face of grave threats and dissipating the impetus for more profound changes.

The outcomes of many development-oriented projects that can also have positive adaptation benefits in Kolkata and Dhaka are often hampered by such institutional constraints. One example is an ADB-financed sanitation and hygiene-improvement project implemented by the KMC, for a slum in Kolkata. According to the performance audit conducted by an external consultant for ADB, it was found that the project, whose scheduled completion date was for the end of 2007, was delayed until June 2012 because of "gaps in planning, deficient contract management and ineffective monitoring." (Working Group on Environmental Auditing, 2011). The findings pointed to two central concerns. First, the lack of coordination between different management units (e.g., sewer and drainage with canal de-siltation), led to only partially satisfactory outcomes Second, delays in the implementation of the project also arose from poor management and scheduling of work of external parties who were engaged to execute parts of the project by KMC. The slum sanitation project, which incorporated aspects of development and adaptation, if planned and implemented properly would have been a successful application of the no-regrets approach. However, since the key institutional challenges were not resolved at the onset, the project not only resulted in severe delays but the outcomes were also less than satisfactory.

Doing more with less

Dhaka, though the more resource-constrained of the two cities, has made greater progress in climate adaptation.. Kolkata, on the other hand, has not made nearly as much headway at the city level. These cities share so many obvious similarities—among them environmental risks, culture, and developmental challenges—yet the substantial disparity in financial resources has not translated into greater progress on risk reduction for Kolkata. My comparative analysis, therefore, should lead to consideration of other institutional factors besides resource availability in analyzing the drivers of successful climate-change adaptation efforts. City-level agencies in Dhaka have effectively drawn upon the leadership, expertise, and accountability provided by national and international organizations to enhance the capabilities of local agencies and actors. Dhaka's success in climate-change adaptation reflects the ability of local organizations to work around limited financial means and insufficient technical knowledge.

MAKING A CASE FOR CONTINGENT APPROACHES

In *The Weather of the Future*, Heidi Cullen notes that global warming "has been called the *perfect problem* – perfect in the sense that is hard to see and challenging to solve." Moreover, she argues that human beings are not wired to act upon what seem like very distant problems. Just because the forecasts of climate scientists, for example, may find a three-foot global sea-level rise accompanied by an increase in average temperatures of 11°F by 2100, this does not mean that people will take cognizance of the risk. In a Pew Research Center study, even in developed countries like the United States, "global warming" has ranked at the bottom of the list of twenty national priorities (Kohut et. al., 2009).

In cities of South Asia, the same argument can hold true that national priorities need to address the most urgent problems, those that will not only raise the standard of living for the largely impoverished residents of these cities but will also address the most urgent problems such as access to potable water, basic sanitation and even shelter. And of course economic development remains key to the well being of these cities and in turn generates the resources to address all these pressing issues. Since the ushering in of the neo-liberal era in India and Bangladesh in the 1990s, this focus on economic growth and development has been the mantra of public agencies of both countries, right from national to city levels.

The effects of climate change resulting from global warming are now neither invisible nor uncertain. Coastal mega-cities of South Asia are already experiencing some of the effects of climate change, including more frequent and intense storms, changes in rainfall patterns, and degradation of groundwater resources. These impacts interact with a number of non-climatic factors to create a series of palpable urban risks, from the continued destruction of urban wetlands to the scarcity and quality of local water supplies.

The original challenge was to enable stakeholders to relate to uncertain climate risks and to plan for uncertain impacts in the distant future. The challenge now is to adapt to the already occurring impacts of climate change and, to climate-proof communities for years to come.

Justification

In South Asian mega-cities, the need for climate adaptation is thus both urgent and necessary; adaptation efforts, however, have not yet gained the kind of momentum needed to effect broad-based changes. Moreover, *resource constraints*, several *institutional limitations*, and the comparatively *lesser likelihood of adoption of adaptation-oriented projects* over other larger developmental goals, all remain real hurdles to implementing such adaptation measures.

This dissertation thus attempts to navigate these contextual complexities to find an approach that lends itself easily to tangible, practice-oriented applications, such that climate adaptation can be addressed in cities such as Kolkata and Dhaka.

According to my research, in investigating a range of projects currently planned or being implemented in Kolkata and Dhaka by city-level agencies in conjunction with national and international partners, I found several initiatives that do address key adaptation needs. Of those evaluated, I identify and analyze three projects that have had successful outcomes: these efforts have been able to fulfill their stated objectives and also successfully surmount the three barriers to adaptation planning noted earlier. These projects, detailed in chapter 5, include the Dhaka Infrastructure Flood Protection Plan, The East Kolkata Wetlands System Management Project and the recently completed Dhaka TurnAround Program. Two additional considerations, apart from their successful outcomes, make these projects worth analyzing. First, these climate-adaptation initiatives are generally "coupled" with common development activities, enabling synergies with growth-oriented efforts. More important, these coupled initiatives are as much a response to the cities' most urgent adaptation needs—namely flood management, protection of urban wetlands and improvement of supply and quality of water—as they are projects designed to advance the cities' larger planning agendas.

Thus the framework for "contingent approaches" to climate adaptation stems from an analysis of such ongoing planning initiatives that traverse this adaptation-development spectrum; the central tenet for such approaches arises from two seminal considerations. "Early adaptation will be more effective and likely cheaper than delay"; it thus would "make sense to seek pragmatic, existing and quicker mechanisms" to fulfill urgent adaptation needs (Dovers & Hezri, 2010), as seen in cities such as Dhaka and Kolkata. To do this, I suggest a "contingent adaptation approach."

> *...a planning approach that articulates adaptive criteria at its inception, fulfills specific long-term adaptation goals, and in the interim serves as a viable substitute for dedicated adaptation planning; the precise elements of this approach are contingent upon the developmental goal* in question (e.g., augmentation of the urban water supply).

If adaptation gaps have to be bridged, then the strategies can no longer be viewed in isolation, particularly at the local public-agency levels.[9] The most effective and readily applicable approaches are those that factor in development and adaptation criteria in an integrated way. In doing so, the *resources allocated for local development can simultaneously address*

[9] The emphasis on the need to integrate adaptation with development is not new to the climate literature. As discussed earlier, several scholars (including Susskind 2010; Schipper, 2007) have made this argument. Climate change is closely interconnected with issues such as water resources and biodiversity, and therefore should be addressed within an integrative policy agenda. Consequently, not isolated sectoral responses, but rather *integrated* approaches are needed to address climate-change concerns effectively (Dovers & Hezri, 2010; WCED 1987). Though the scholarly consensus argues that adaptive responses should be integrated with pertinent larger development projects *across* various sectors, my evaluation of the National Climate Action Plans of India, the State of West Bengal, and Bangladesh reveals that climate-adaptation and mitigation efforts are actually focused on *individual* sectors

adaptation needs for the city without substantial additional investments, which is an important consideration for local agencies in resource-constrained regions. Moreover, since such projects are already part of the ongoing planning initiatives, they do not require more extensive "specialized adaptation" planning and technical expertise. A contingent perspective thus does not overtax the often-limited capacities of local agencies.

Enabling Contingent Adaptation

The identification of readily applicable, cost-efficient types of adaptation approaches (i.e., "contingent approaches") that can be integrated with existing developmental initiatives is only part of the story. Equally important is finding some way to cover the costs and some way of reforming the institutional arrangements that get in the way of making collective risk management decisions in a timely fashion Many such barriers defy easy thematic characterization, given the interdependencies and situational complexities. However, my analyses of several projects in Kolkata and Dhaka, as well as other scholarly evidence, suggest three common determinants of the success of local adaptation efforts, even in the face of financial and institutional difficulties.

Resource Constraints

The first determinant to a municipality's ability to move forward with contingent adaptation measures is the availability of financial resources. Resource constraints have been cited as a primary and frequent barrier for planning activities at the local level, especially in developing countries (see, for example, Pini et al. 2007; Dovers & Hezri, 2010; Stakhiv, 1998). The inadequate financial capacity of local planning agencies has been attributed to their limited institutional autonomy and to the wide range of often conflicting priorities that dilute their efforts (Measham et al., 2011). This in turn leads to "reactive management of facilities and infrastructure", "inhibits life-cycle planning" (Brackertz and Kenley, 2002) and leads to "short-term technical fixes rather than long-term integrated approaches"(Crabbé and Robin, 2006).

My analysis of existing planning activities in Kolkata and Dhaka suggests similar conclusions. Apart from the absolute local budgetary constraints (discussed in chapters 1 and 4), both the DCC and KMC attend to a broad array of planning and service activities. For example, KMC currently has over forty departments, which cover an extraordinary breadth of activities—planning, monitoring, implementation, record-keeping, licensing, feasibility studies and maintenance—across a wide range of sectors, including parks and recreation, water supply, and electricity. Reports and analyses of KMC's performance also confirm that the agency relies on reactive management, as seen most clearly in its flood-emergency operations and maintenance of water infrastructure. Moreover, KMC takes short-term approaches to many of its ongoing water supply projects. Its construction of tube wells to meet water-supply needs, for example, not only increases the depletion of groundwater and saline contamination, but also ignores the considerations of project life-cycle costs or integration of longer-term adaptation goals.

My analysis of the three illustrative projects I presented in Chapter ??that overcome inherent resource-constraints indicates that local agencies do have the capacity to acquire the resources needed to fund climate adaptation measures

- *Internally initiated organizational actions can help reduce resource deficits* (sometimes without the need to resort to external aid).

  These include increasing operational efficiency (and saving money in the process), consolidating existing revenue sources and coupling existing planning initiatives to address multiple concerns simultaneously. Dhaka WASA was able revise existing tariffs to increase its tax base, streamline payment processes, and reorganize and consolidate its revenue territories. Several organizational actions enabled DWASA to achieve these financial and operational improvements. The first relies upon the professional development of its middle managers; the agency has made significant efforts to enhance the knowledge and skills of its employees, including seminars on procurement, customer relations, and financial controls (*The Financial Express*, 2012). The second focuses on building positive customer relationships, through offering on-line and mobile-based payment options, instituting longer hours of operation for public offices, and providing payment kiosks throughout the city (*The Financial Express*, 2009; *The New Nation*, 2012). The third involves strategic decision-making that takes into account the inherent limitations of Dhaka's infrastructure. In 2012, for example, DWASA purchased generators for nearly all of its groundwater pumps; the frequent summer power outages in Dhaka had often prevented operation of the pumps and thus resulted in significant water shortages (*The Financial Express*, 2012). In 2010, DWASA took the unprecedented step of seeking to evict residents who had encroached on the Muhammadpurs Ramchandrapur and Kalyanpur Canals, a crucial link in the city's drainage system. Finally, DWASA has obtained external funding—grants and loans—from a wide variety of sources, including the ADB, the UN, and the Malaysian and Danish governments (*The Financial Express*, 2012). As a result of these and other innovations, the Global Water Conference named DWASA "Water Performer of the Year" (*United News of Bangladesh,* 2011).

These actions, along with a range of others (discussed in detail in chapter 5) allowed DWASA to achieve financial autonomy and make significant service improvements, including addressing infrastructure concerns to increase the adaptive potential of the city's water supply. By "coupling" planning objectives, the East Kolkata Wetland Systems (EKWS was able to address issues of water supply, sewerage, and food production concurrently (Sarkar, Ghosh, Mukherjee, Sil, and Saha, 2009).

- *Cooperation with external organizations can also increase the likelihood of finding outside financial support.*

Purely local efforts may not be feasible when projects require the collaboration of multiple agencies (from national to local levels) and must satisfy the interests of a wide number of entities, as seen in the case of the Dhaka Integrated Flood Protection Project (DIFPP). In such cases, local agencies can generate additional revenue through strategic partnerships with international donors (such as the UN, World Bank, or ADB). Local governments can also ally with the national government and align their projects with the objectives of external organizations in order to satisfy both broader and local infrastructure and adaptation needs. This is again demonstrated in the DIFPP, where DCC, DWASA, and RAJUK (other local agencies) aligned with the broader priorities of the national government and international agencies to address flood abatement and gathering larger funding pools to expand local development in an adaptive fashion. City-level agencies were able to rehabilitate drainage and road infrastructure and upgrade slum areas at the same time..

Institutional Limitations

Climate change may indeed represent a sea change in the history of human society, one that requires radical overhaul of the ways in which institutions operate. Unfortunately, researchers have devoted insufficient attention to the need for such institutional changes (Dovers & Hezri, 2010). Given that such limitations can constrain or enable adaptation, institutional structures must be recognized as a key determinant of the adaptive capacity of municipal agencies (Measham et al., 2011; Dovers & Hezri, 2010; Nelson, Adger, Brown, 2007; Brooks, Adger, Kelly, 2005). My analysis of planning efforts in Kolkata and Dhaka (see chapters 1, 4 and 5) mirrors the findings of other researchers and shows that existing institutional and local policy frameworks are largely shaped by the concerns of state and national governments as well as of international donors (Measham et al., 2011; Wild River 2006; Ivey et al. 2004).

In Kolkata and Dhaka, institutional limitations take many forms. Issues of coordination (both horizontal and vertical), general institutional reluctance to initiate adaptation-related planning, gaps in technical and human capacities, and invasive political influences[10] can hinder the successful implementation of adaptation projects. I found that establishing appropriate hierarchic reporting structures and clarifying jurisdictional responsibilities can lead to increased accountability, enhanced performance, and, most important, resolve issues of coordination. Three ways in which local agencies can promote contingent adaptations emerged from my fieldwork. The first two relate to institutional modifications, while the third has implications for reducing technical and human-capacity gaps:

- *Modification of existing organizational structures can reduce institutional barriers and increase organizational performance.*

[10] Such political interference is quite common in South Asia. For example, as discussed in chapter 4, KMC was forced through political pressure to redesign an entire pipeline. Additionally, DWASA was forced, at substantial cost, to remove a pumping station in Dhaka (through a High Court ruling) so that a park in a wealthy area of the city could be restored (*The Financial Express* 2011).

- *Streamlining intra- and inter-organizational coordination can lead to more effective project management and implementation while increasing accountability.*

- *Strategic collaboration and selective outsourcing can help address capacity gaps.*

Such institutional modifications are referred to as "institutional resilience strategies" or "how institutions contemplate adaptation in the face of disturbance" (Handmer and Dovers, 2007, 1996). Institutional modifications can be represented in terms of: resistance and maintenance, change at the margins, and openness and adaptability (Dovers & Hezri, 2010; Berkhout, Hertin, Gann, 2006).

Of these, openness and adaptability can be seen in the radical organizational reform of DWASA as well as in the formation of KEIP. Openness and adaptability require agencies to recognize the uncertainty that characterizes climate-adaptation projects and to adjust policies and procedures in light of changing circumstances (Dovers & Hezri, 2010). Both DWASA and KEIP created autonomous agencies. All aspects of planning and co-ordination of projects were under their control, though both agencies cooperated closely with other city-level agencies and national and international organizations. Setting project objectives and managing implementation remained in their hands, though.. These institutional arrangements led to increased organizational performance and accountability. In both cases, the projects initiated by these agencies were able to overcome a series of institutional limitations to achieve successful outcomes in augmenting water infrastructure adaptively (in the case of DWASA) and preserving and maintaining the East Kolkata Wetland Systems effectively while expanding on the project's adaptation potential (as in the case of KEIP). Additionally, DWASA achieved relative financial stability through radical operational efficiencies and stricter enforcement of tariffs, while KEIP did so through external ADB funding, enabling both agencies to operate largely independently of political pressures.

The local agencies in Dhaka (DCC, RAJUK, and DWASA), in collaboratively implementing the DIFPP with national governments and international agencies, made institutional modifications that can be categorized as "Change at the Margins". This occured when organizational modifications were based on "well-considered reactions to new understanding and pressures" and take the form of "manageable, incremental responses" (Dovers & Hezri, 2010). In the case of the three public agencies of Dhaka, the institutional limitations (particularly those related to streamlining coordination and implementation and to increasing accountability) were overcome by clearly demarcating responsibilities within organizations and among other local/state national agencies at project inception. In addition, the inclusion of key representatives (from collaborating agencies) based on individual organizational capacities and prior experience, and the establishment of distinct reporting hierarchies for efficient project management, were also major contributing factors for DIFPP's success.

Lastly, all three projects—the TurnAround Program, the EKWMP and the DIFPP–were completed successfully because their primary implementing agencies or multi-agency collaborations (as in DIFPP) were able to bridge the institutional gaps of human and technical capacity. Having one agency to champion and spearhead the project enables both greater accountability and clearer coordination among involved organizations. For example, DWASA outsourced peripheral functions, such as billing procedures and revenue collection, to address its gap in human resources, while KEIP hired wetlands experts for the project duration to ensure that the technical components of the EKWMP would be duly addressed. In the case of the DIFPP, multiple agencies at the national and local level collaborated on individual project components, lending their specific expertise to tackle the varied elements of the project. For example, BWDB's prior experience with building flood embankments and DWASA's expertise in drainage infrastructure were important technical contributions to the project.

Building Support for Contingent Adaptation

In resource-constrained environments, where climate adaptation is often neglected, identifying "climate" projects that can simultaneously support the city's developmental objectives are essential for bringing climate adaptation to the fore. In the absence of "formal" adaptation plans, ongoing projects that couple specific growth or development objectives with climate-adaptation or vulnerability-reduction measures offer the best likelihood of advancing climate-adaptation agendas in big cities in developing countries. As we see in the case of Kolkata and Dhaka, existing planning initiatives, such as the building of sewer and storm drains, treatment plants, pumping stations, and water supply infrastructure, have occasionally been "coupled with" urgently needed climate-related action, such as flood control or ecosystem preservation..

The three projects that were identified for detailed analysis for this dissertation (see chapter 5) not only integrated adaptation and development, but also operated on a scale large enough to affect the broader urban region. Equally important, these projects were able to overcome resource constraints and a range of institutional limitations. In the interests of advancing similar projects that fulfill these criteria, the pertinent question is: *what factors can increase the likelihood of contingent adaptation being adopted?* These projects entailed a number of successive decisions, each of which was contingent upon the local context and the results of initial actions. The analysis of the three projects points to two key factors that can enable support for adoption of such approaches:

- *The likelihood of adoption of such contingent adaptations rises when overall political commitment and support increases*

  and

- *when such projects are integrated into existing planning initiatives with the consideration of clear adaptation criteria at the onset.*

The first factor, which other scholars (e.g., Garrelts & Lange, 2011, in their research on flood-risk management in Germany) have identified as crucial, relies upon "the pivotal role of the state."[11] This is particularly true in Bangladesh, where the national government has taken a leadership role in advancing climate-related action (Alam et al., 2011). This influence was deeply felt in Dhaka itself, where numerous interviewees mentioned the government's leadership as a central factor in furthering climate-related activities. In fact, the Bangladesh government spearheaded the DIFPP in Dhaka; this strong political commitment proved largely responsible for the project's success. This commitment translated into financial support not only from the central government, but also from external donors, as the

[11] The authors also note the importance of engaging civic stakeholder groups, including scientists and other academics, NGOs, citizens' organizations, and mass media. Such actors bring expertise and local knowledge and can shape public discourse and mobilize significant support for climate action. These groups have furthered adaptation actions and influenced climate-related policy, particularly in Bangladesh.

government lobbied for funds from ADB to make up for local resource deficits. In addition, despite the complexity and scope of the project, which overlapped multiple developmental objectives, DIFPP successfully carried out these flood protection measures. The state was instrumental in aligning the pertinent agencies to collaborate on this project, while also seeking external foreign consultants (e.g. JICA) to assess and support the project technically.

In Bangladesh, the role of champions in the form of state actors is not limited to the national government. The managing director of Dhaka WASA was instrumental in reforming the agency. Under his leadership, DWASA became an independent agency with relative financial independence that was able to collaborate across the city and national levels. Moreover, the agency has furthered adaptation through appropriate infrastructure augmentation, such as surface water treatment plants. Again in the case of Bangladesh, many interviewees characterized the Minister of the MOEF as a champion for climate adaptation. It was under his guidance that independently operating agencies, such as the Climate Change Unit, have been established to further adaptation efforts in the country.

Before selecting the projects discussed in depth in chapter 5, I examined a number of efforts across the two cities. In Kolkata or in the State of West Bengal, similar state-furthered efforts did not exist. Moreover, the number of projects that contain elements of what I term "contingent adaptation" is also lower than that in Bangladesh. Most of the projects that do address adaptation needs through existing developmental initiatives, such as the EKWS project (as well as other water supply and drainage projects), are all initiated and directed by international agencies such as the ADB rather than by the local or state actors. As discussed earlier (in chapter 4), Dhaka is more engaged and further along in pursuing adaptation efforts than Kolkata, despite the former's severe resource constraints, largely because Dhaka enjoys far greater political commitment and leadership.

The second factor that increases the likelihood of implementation of such projects is that they are integrated into existing planning activities. Such instances, seen both in Kolkata and Dhaka (in the wetlands and water supply projects, respectively), provide two ancillary benefits apart from their adaptive potential. First, such projects can address multiple developmental agendas at the same time and do not require large investments outside of those required for such development aims. This efficiency works well for resource-constrained local agencies. Second, integrating adaptive components into existing planning initiatives satisfies the different objectives of various agencies simultaneously, while fulfilling many of the planning requirements of the cities. For example, the wetlands management project of East Kolkata met a number of goals: it reduced vulnerability to water-logging in some areas of Kolkata and augmented drainage capacities, thereby obviating the need for additional treatment plants for adjoining areas. The project also furthered the economic development of the local people who used these wetlands for agriculture and aquaculture.

Another important consideration, which increases the likelihood of adoption of such projects and maximizes the realization of adaptation benefits, is to design developmental projects with clear adaptation criteria in mind, as was the case in all the three illustrative projects considered in this dissertation. In all these projects, the responsible city-level agencies considered a range of adaptation criteria alongside developmental objectives so as to address multiple aims simultaneously. The developmental goals included the construction of primary roads at adequate elevations to ensure access to transportation networks during floods (as in the DIFPP) and designing water supply systems, principally drawing upon surface-water sources, to increase water supply and decrease groundwater contamination and depletion (as in Dhaka's TurnAround Program). In addition, in the EKWSMP, storm and sewer systems were de-silted and augmented to increase network capacities, thereby reducing the risks of overflows, contamination, and water-logging. These projects protected environmentally sensitive locations, such as flood zones and wetlands, as part of the project objectives as well.

SIGNIFICANCE OF RESEARCH

In advancing context-specific approaches that are readily applicable to planning practice more generally, I hope to make a contribution to the understanding of how major cities in South Asia can address climate risks under present circumstances. The specific focus of this work reflects two considerations. First, context matters. In fact, both the degree of vulnerability and severity of likely impacts vary greatly among nations and regions. We must thus examine each climate intervention in light of its unique characteristics. Second, all adaptation is ultimately local. Although broader adaptation agendas will flow from regional, national, and international policies, the actual implementation of these agendas will happen at smaller scales, where local stakeholders' "place-based" knowledge of particular challenges and opportunities can lead to more successful outcomes (Dovers & Hezri, 2010; Lane and McDonald 2005; Li 2002).

Thus, after identifying the nature and types of adaptation-oriented projects that have been successful in this context, I propose the notion of *contingent adaptation*, as a way of overcoming a troubling gap in local adaptation planning.

While several researchers have recognized that institutional constraints pose serious barriers to adaptation, they have not yet explored the nature of the institutional changes needed to promote adaptation more widely (Dovers & Hezri, 2010; Yohe et al., 2007) In addition, the recurring barrier of local resource constraints also needs to be addressed. Through my analysis of three successful adaptation-oriented projects, I seek to provide both a framework for the types of institutional change that can facilitate the effective implementation planning initiatives and enable local agencies to overcome financial and technical limitations and build broader support for contingent adaptations. My findings provide recurring support for the argument, outlined by Susskind, that effective adaptation strategies must be action-oriented, adaptive, strategic, and broadly supported (2010: 220).

My cross-case analysis of two mega-cities provides insights into how disparities in resources can shape adaptation strategies, while highlighting the factors that permit effective vulnerability reduction and resilience enhancement even in the face of resource constraints. The largely similar conditions present in the cities of Kolkata and Dhaka, in terms of the climate risks they face and the institutional arrangements with which they must deal, enable these cities to serve as proxies for testing the effectiveness of alternative adaptation approaches. In Asia alone, conditions comparable to those found in Dhaka and Kolkata can be identified in eleven major coastal cities, each of which is not only threatened by similar climate-change risks, but also hindered by limited resources.[12]

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[12] According to *Mega-Stress for Mega-Cities: A Climate Vulnerability Ranking of Major Coastal Cities in Asia*, a report prepared by the World Wildlife Fund (2009), eleven coastal cities with similar geographical and climatic attributes were assessed as extremely vulnerable to similar and significant impacts of climate change. These prototypical cities of coastal Asia include: Dhaka, Bangladesh; Jakarta, Indonesia; Manila, Philippines; Calcutta, India; Phnom Penh, Cambodia; Ho Chi Minh City,

Examining the selected "keystone" challenges faced by the water sector in the face of climatic risk—water supply and quality, stormwater management, and urban wetlands—allows for a deeper understanding of the intrinsic limitations of each city's response and of how efficacious climate-adaptation strategies can be shaped. This research should enhance our knowledge of how to implement successful climate-adaptation strategies not only in India and Bangladesh but also in other urban areas of the Global South. This work fills an unmet need, both in planning practice and the climate-adaptation literature, for a greater understanding of climate planning that can be applied to coastal megacities of the developing world.

LIMITATIONS AND FUTURE DIRECTION

In my work, I have proposed a planning approach that South Asian urban local agencies can employ to advance adaptation in conjunction with ongoing developmental initiatives. I also explore more broadly applicable strategies to overcome resource constraints, achieve broader support, and stimulate the institutional changes needed to increase the effectiveness of adaptation planning. Though this research tries to bridge crucial gaps in the literature by a cross-case analysis of two bell-weather cities in South Asia, significant work still needs to be done to expand on the concept of "contingent adaptation" and its application.

Insofar as this work principally focuses on Dhaka and Kolkata, my conclusions and resulting policy recommendations may prove less relevant in contexts other than South Asia. Conducting similar research in coastal cities of other nations or regions would allow for a more definitive determination of the wider applicability of contingent adaptation approaches. Cities of South-East Asia such as Ho Chi Minh City, Vietnam, Manila, The Philippines, and Jakarta, Indonesia, for example, share many characteristics with the cites selected for this study, including similar problems with flooding, drainage congestion, water supply, and wetlands preservation, and might therefore offer additional invaluable insights. Other avenues for future scholarship include examination of other fields related to climate, such as energy or agriculture, to determine

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Vietnam; Shanghai, China; Bangkok, Thailand; Hong Kong, China; Kuala Lumpur, Malaysia; and Singapore.

whether the same results have occurred in other areas. Thus, investigation into whether the approaches outlined here hold validity across other regions and sectors would offer significant value for those planning for climate change.

Ultimately, "Adaptation brings us back to the issue of planning" (Giddens, 2009). What my research tells us about climate adaptation comes principally through the lens of urban planning; this dissertation should therefore provide a basis for increased appreciation of effective planning practice in developing nations. The contingent approach explored here may thus have implications for a broad range of public policy and development issues.

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APPENDIX 1: LIST OF INTERVIEWEES

(The interviewees have been sorted by agency affiliations. Please note that some of the respondents' names and/or positions have been suppressed to ensure confidentially as requested).

DHAKA, BANGLADESH

1. National agency representative 1; January 2011
2. National agency representative 2; January 2011

Ministry of Environment & Forest (MOEF), Government of Bangladesh

3. Dr. Md. Moniruzzaman, Director Of Deputy Secretary, Climate Change Unit (CCU); June 2012
4. Md. Rafiul Alam Siddiqui (Sumon), Assistant Director (Admin &Finance) CCU; June 2012 and January 2011
5. Md. Rashadul Islam, Director (Deputy Secretary), Climate Change Unit; June 2012
6. Ahmadul Hassan, Senior Water Resources Planner, Director R&D and Training Division, Center for Environmental and Geographic Information Services (CEGIS); January 2011
7. Mr. Didarel Ahsan, Additional Secretary, Climate Change Unit; January 2011
8. Representative, Climate Change Cell; June 2012
9. Senior Official; June 2012

Department of Environment, Government of Bangladesh

10. Mohammed Solaiman Haider, Deputy Director (Technical); June 2012 and January 2011
11. Monowar Islam, Additional Secretary; January 2011

Bangladesh Planning Commission

12. M. Mahmud Ali, Senior Assistant Chief; January 2011
13. Officer; January 2011

Bangladesh Power Development Board

14. N. M. Belal, Deputy Director, Directorate of Personnel; June 2012

Road and Highways Department, Government of Bangladesh

15. Shishir Routh, Execeutive Engineer; January 2011
16. Officer; June 2012

Bangladesh Water Development Board, Government of Bangladesh

17. Md. Sharafat Hossain Khan, Superintending Engineer/Director; June 2012
18. Md. Belal Uddin Biswas, Senior Assistant Chief, Environment and Forestry; June 2012
19. Officer 1; June 2012 and January 2011
20. Officer 2; June 2012
21. Senior employee; June 2012

Disaster Management Bureau, Government of Bangladesh

22. Dilder Ahmed, Director, June 2012
23. Shahnaz Rub, Deputy Director, June 2012
24. Officer; January 2011

Dhaka Water and Sewerage Authority (DWASA), Dhaka City

25. Md. Mahbubur Rahman, Joint Secretary; June 2012
26. Md. Jafrin Hossain, Senior Systems Analyst; June 2012
27. S.D.M. Quamrul Alam Chowdhury, Chief Engineer; June 2012
28. Md. Taqsem A Khan, Engr., Managing Director; June 2012
29. Senior Director; June 2012
30. Director; June 2012
31. Officer; June 2012
32. Senior Engineer; June 2012
33. Senior Official; June 2012

Dhaka City Corporation (DCC)

34. Mohammad Sirajul Islam, Chief Town Planner, Urban planning Department; June 2012
35. Senior Employee, DCC (South); June 2012
36. Officer 1; June 2012
37. Officer 2; January 2011

Rajdhani Unnayan Katripakkha (RAJUK)

38. Senior Official; January 2011
39. Officer, Town Planning; January 2011 and June 2012
40. Officer, Development Control; June 2012
41. Engineer 1; January 2011
42. Project Director 1; June 2012

43. Project Director 2; June 2012

University of Dhaka

44. S.M. Mahbubur Rashid, Lecturer, Department of Civil Engineering; January 2011
45. Dr. Zerina Begum, Professor, Institute of Information Technology (IIT); June 2012
46. Mohd. Zulfiquar Hafiz, Associate Professor, Institute of Information Technology (IIT); June 2012
47. Mustak Ibn Ayub, Lecturer, Department of Genetic Engineering & Biotechnology; January 2011
48. Dr. Zeba Islam Seraj, Professor, Department of Biochemistry & Molecular Biology; January 2011
49. Dr. M. Imdadul Hoque, Professor, Department of Botany; June 2012
50. Dr. Ahmad Islam, Professor (retired), Department of Molecular Biology; January 2011 and June 2012

Bangladesh University of Engineering and Technology (BUET)

51. A.K.M. Saiful Islam, Associate Professor, Institute of Water and Flood Management; June 2012
52. Dr. Md. Kabirul Islam, Consulting Engineer and Professor, Department of Civil Engineering; January 2011

The International Union for Conservation of Nature (IUCN), Bangladesh

53. Md. Kamruzzaman, Programme Officer; June 2012

Bangladesh Centre for Advanced Studies

54. Dr. A.Atiq Rahman, Executive Director; January 2010
55. S. M. Shah Jalal, Executive Secretary; January 2010

International Centre for Climate Change and Development

56. Ina F. Islam, Assistant Director; June 2012

World Bank, South Asia

57. Winston Yu, Senior Water Resources Specialist; June 2012
58. Sanjay Kathuria, Lead Country Economist, Bangladesh; June 2012

KOLKATA, INDIA

Environmental Department, Ministry of Environment and Forest, State Government of West Bengal

59. K.S. Rajendra Kumar, IAS, Addl. Chief Secretary; December 2010
60. Officer 1; December 2010
61. Officer 2, December 2010

Irrigation & Waterways Department, Government of West Bengal

62. Anjan Kumar Chatterjee, Secretary
63. Senior Official; May 2012

West Bengal Biodiversity Board, Government of West Bengal

64. Debal Ray IFS, Chief Environment Officer, Member Secretary; December 2010 and May 2012

West Bengal Pollution Control Board

65. Dr. Tapas Kr. Gupta, Chief Engineer

Kolkata Municipal Corporation (KMC)

66. Debasish Kar, Director General; December 2010
67. Senior Officer, Water and Sewer Department; December 2010
68. Senior Officer, Building Department; December 2010
69. Officer 1; May 2012
70. Officer 2; May 2012
71. Officer 3; May 2012
72. Water Engineer 1; May 2012
73. Water Engineer 2; May 2012

Kolkata Metropolitan Development Authority (KMDA)

74. Vivek Bharadwaj, I A S, Chief Executive Officer; December 2010 and May 2012
75. Smt. Smita Pandey, IAS, Special Secretary (Environment) December 2010 and May 2012
76. Kalyan Ray, Advisor (PPP); December 2010
77. Srabani Sengupta, Team Leader, Project Management Unit (JNNURM), IPE Global; December 2010 and May 2012
78. Rajat M Chatterjee, Director General Operation; December 2010
79. Officer 1; May 2012
80. Planning Officer; December 2010

Kolkata Environmental Improvement Project

81. Susit Kumar Biswas, IAS, Project Director; December 2010
82. Dr. Chinmoy. Chakraborty, Wetlands Environmental Specialist (project consultant); December 2010
83. A.K. Chatterjee, Sr. Construction Supervisor (on deputation from KMC); December 2010
84. Soumya Ganguly, Director General (on deputation from KMC); December 2010
85. Project Director; May 2012
86. Senior Official; December 2010
87. NGO representative; December 2010
88. Official 1; May 2012;
89. Official 2; May 2012
90. Engineer (on deputation from KMC); May 2012

Jadavpur University

91. Dr. Arunabha Majumder, Professor, Emeritus Fellow, School of Water Resources Engineering; December 2010
92. Dr. Dipankar Chakravarty, Professor, Civil Engineering, School of Environmental Studies; May 2012

Baligunge Science College

93. Dr. Sunanda Ghosh, Geographer; May 2012
94. Professor, Area of Expertise: Disasters; December 2010

Commission of Ecosystem Management

95. Dr. Dhrubajyoti Ghosh, Regional Vice Chair South Asia, East Kolkata Wetlands Systems Champion; December 2010

Environmental Activist

96. Dr. Mohit K Ray, Environmental Consultant; May 2012

APPENDIX 2: INTERVIEW TEMPLATE

(Please note that the following template was used as a guide to create the actual interview instruments, where each interview was tailored to best match the respondent's experience).

POLICIES/PROJECTS/ INITIATIVES: DEVELOPMENTAL, INFRASTRUCTURAL

General

- Description (Duration), Risk Addressed
- Relevant Documents/Plans (Sources: Archival/Individual/Other)
- National/International visibility
- Motivation for Project (developmental, infrastructural deficit/ augmentation)
- Motivation based on or to address perception/ events leading to climate risk (past disasters, current deficiencies)
- Relevant Documents/Plans (Sources: Archival/Individual/Other)

Funding/Resources

- Budget
- Anticipation of other funding/resources
- Funding Source(s)
- Reallocation/ redistribution of existing resources and funding (how, by whom, why)

Objectives/Goals

- Developmental/Infrastructural goals addressed. What other infrastructural/developmental needs does it fulfill?
- Did this include any Climate Change Risks to be addressed/ how
- Was it intended as such? If not, what were the primary goals of this initiative?
- Relevant Documents/Plans

Institutional/Other

- Initiated by which institution(s) and at what level (national, state or city)
- Initial Institutional problems
- Institutional Motivation/ Triggers for Reform
- Institutional Restructuring
- Institutional Collaborations

- Awareness/ participation of civil society
- Role of Champions

Operational

- Level of implementation/ Success
- Implementation/ Regulation (by, how)
- Implementation (Augmentation and coordination--anything different)
- Strengths/weaknesses in operations
- Benefit/Outcome of project/ Indicators of success

EVALUATION OF PROJECT-SPECIFIC ADAPTATION COMPONENTS

- Indicators for success/ failure - project level
- Factors contributing to success and or failure/drawbacks - project level
- Were there any explicit Policies and planning measures, which address these climate risks (or serendipitous)
- What climate risks does it address?
- How are these climate risks assessed?
- Were there any Coupling of Resources (infrastructural, Institutional, etc. for this)?
- Synergies between any of the sectors
- Indicators for success in addressing climate risk
- Were there any synergies between disasters and climate risk management?
- Was there any Assessment/ documentation of Climate Risk
- Is there any documentation/ dissemination of climate risks addressed (to serve as a model)
- Were there any Planning/developmental/ infrastructural objectives coupled for synergistic outcomes to address climate risks?
- Was there Integration of new objectives with existing projects to address climate risks?
- Cost vs. Risk reduction
- Productivity and Impact
- Social Benefits and innovation

APPENDIX 3: LIST OF FIGURES AND TABLES

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APPENDIX 4: LIST OF ABBREVIATIONS

ACA Asian Cities Adapt
ACCCRN Asian Cities Climate Change Resilience Network
ADB Asian Development Bank
AFD Armed Forces Division
BCCRF Bangladesh Climate Change Resilience Fund
BCCSAP Bangladesh Climate Change Strategy and Action Plan
BCCTF Bangladesh Climate Change Trust Fund
BOD Biological Oxygen Demand
BSCIC Bangladesh Small and Cottage Industries Corporation
BWDB Bangladesh Water Development Board
CCFVI Coastal Cities Flood Vulnerability Index
CDMP Comprehensive Disaster Management Programme
CDP City Development Plan
CMWSA Calcutta Metropolitan Water And Sanitation Authority
COD Chemical Oxygen Demand
CSO Combined System Overflows
CSS Combined Sewer Systems
DANIDA Danish International Development Authority
DAP Detailed Area Plan
DCC Dhaka City Corporation
DESC Dhaka Electricity Supply Company
DEP Department of Environmental Protection
DGA Design Ground Acceleration
DIFPP Dhaka Integrated Flood Protection Project
DMB Disaster Management Bureau
DMC disaster management committee
DMCC Disaster Management Coordination Committee
DMDP Dhaka Metropolitan Development Plan
DMRD Disaster Management and Relief Division (DMRD),
DOE Department of Environment
DRM Disaster Risk Management
DRR Disaster Risk Reduction
DSEA Dhaka Strategic Environmental Assessment

DSP Dhaka Structure Plan
DWASA Dhaka Water and Sewerage Authority
ECSCSL Employees' Consumers Supplies Cooperative Society Limited
EKWMA East Kolkata Wetlands Management Authority
EKWS East Kolkata Wetland System
EKWSMP East Kolkata Wetland Systems Management Project
ESCAP Economic and Social Commission for Asia and the Pacific
FAO Food and Agriculture Organization
FAP Flood Action Plan
FEMA Federal Emergency Management Agency
FY Financial Year
GDP Gross Domestic Product
GEF Global Environment Facility
GFDL Geophysical Fluid Dynamics Laboratory
GFDRR Global Facility for Disaster Reduction and Recovery
GHG Green House Gas
GOB Government of Bangladesh
GOI Government of India
HBU Highest and Best Use
ICEAB International conference on Environmental Aspects of Bangladesh
ICIMOD International Centre for Integrated Mountain Development
ICLEI International Council for Local Environmental Initiatives
IFPRI Food Policy Research Institute
INCCA Indian Network on Climate Change Assessment
INR Indian Rupee
IPCC International Panel for Climate Change
IUCN International Union for Conservation of Nature
IWD Irrigation and Waterways Department
IWM Institute of Water Modeling
IWRM Integrated Water Resource Management
JICA Japan International Cooperation Agency
JNNURM Jawaharlal Nehru National Urban Renewal Mission
KEIP Kolkata Environment Improvement Trust
KMA Kolkata Metropolitan Area
KMC Kolkata Municipal Corporation
KMDA Kolkata Municipal Development Authority
KMWSA Kolkata Metropolitan Water and Sanitation Authority
LCD Least Developed Country

LDCF The Least Developed Countries Fund
LECZ Low Elevation Coastal Zone
LGRDC Local Government Rural Development and Cooperatives
MGD Million Gallons per Day
MLA Member of Legislative Assembly
MLD Million Liters per Day
MOEF Ministry of Environment and Forests
NAPA National Adaptation Programme of Action
NGO Non Governmental Organization
NPM New Public Management
OECD Organization for Economic and Co-Operation Development
PIL Public Interest Litigation
PLDC Private Limited Development Corporation
PMO Project Management Office
PMU Project Management Unit
PSC Project Steering Committee
PUBLIC People United for Better Living in Kolkata
RAJUK Rajdhani Unnayan Katripakka (Dhaka Development Authority)
SAWUN South Asian Water Utilities Network
SCFF Special Climate Change Fund
SIDA Swedish International Development Agency
SPA Strategic Priority on Adaptation
SPM Suspended Particulate Matter
SSWA South and South West Asia
SWMC Surface Water Modeling Centre
TERI The Energy and Resources Institute
TMU Technical Management Unit
UCP Urban Climate Project
ULB Urban Local Body
UN United Nations
UNDP United Nations Development Programme
UNESACP United Nations Economic and Social Commission for Asia and the Pacific
UNESCO United Nations Educational, Scientific and Cultural Organization
UNFCC United Nations Framework Convention on Climate Change
WASA Water and Sewerage Authority
WB World Bank
WBPCB West Bengal Pollution Control Board

WTO World Trade Organization
DESA Dhaka Electricity Supply Company
DMRD Disaster Management and Relief Division
DPR Detailed Project Report
EWH Equivalent Water Height
MA Millennium Assessment
PDR Preliminary Design Report
TAPCC Technical Advisory Panel on Climate Change
DAP Detailed Area Plan
WRI World Resources Institute

APPENDIX 5

Summary of Adaptation Strategies in Water Resources in Alluvial Zones (includes Kolkata)

Source: Excerpt from table 1 annexure 1, West Bengal State Action Plan on Climate Change, Govt of West Bengal (draft-April 2012) p. 272.

	Institutions responsible	Actions	Cost in Crores (12th Plan)
B. Alluvial Zone			
1. Increase the reservoir storage potential of existing major irrigation projects	IWRD .	i. Removal of siltation in the reservoirs ii. blocking leakages in the reservoirs iii. Lining the sides of the canal system	Rs.250.00 Cr
2. Recycling of waste water to reuse water for operations in the thermal power plants and in steel plants	NTPC SAIL	i. Assessment of waste water that can be recycled ii. Establishing recycling units	To be absorbed within the budgets of NTPC and SAIL
3. Limit extraction of ground water for limiting arsenic contamination - Formation region specific centralised ground water extraction units	WRIDD SWID IWRD Agriculture Department Panchayet Department	i. identification of deep aquifers ii. Identification of recharge zones iii. Creation of centralized ground water extraction and recharge units iv. Creating distribution systems of this water	i. Rs 1.00 Cr ii. Rs. 1.00 Cr iii. Rs. 50.00 Cr (50% of the units installed) iv. Rs. 50.00 Cr (laying pipeline)
4. Creation of surface water based irrigation schemes - lift irrigation etc)		i. Identifying feasible areas and required water flow ii Create facility for lifting water up and distribution to the fields ii. Maintaining the same through public and community	50 Units for 20 ha each Rs.50.00 Cr

		partnerships	
5. Encouraging rainwater harvesting in ponds in farmers fields - community ponds for small and medium farmers can be encouraged further		i. Formation of groups to form water cooperatives that would look after ponds created in fallow areas and will look after the upkeep of the water structure ii. Educating the people on the appropriate structure that needs to be maintained	Rs.25.00 Cr (25 lakh irrigation facilities)
6. Enhance artificial Recharge activities in over exploited ground water areas (critical Blocks)	WRIDD	i. Build Percolation tanks iii. Contour Bandhs iv. Create subsurface dykes v. RCC Ring wells	i. 500 ha; Rs. 150.00 Cr ii. 25 km; rs. 25.00 Cr iii. 2km, 5 .00 Cr iv. 2500 no.s,; 10.00 Cr
7. Resuscitation of Derelict channel with provision of sluice gates for storing rain water	IWRD	Activities to be further listed	Rs.100 Cr
8. Abatement of floods		i.Re-excavation of existing drainage channel ii. Construction of new drainage channels	Rs. 200.00 Cr
9. Surface water treatment plants		15 schemes each in 12th and 13th plan	Rs.200.00 Cr
10. Schemes for removing arsenic and other heavy metals from water		25 schemes to be completed within 12th and 13th plan respectively	Rs.37.50 Cr
F. Policy related strategies			
1. Modernization of Irrigation system using Drip, Sprinklers systems	SWID, WRIDD, Agriculture Department	i. Undertake feasibility studies ii. Implement	Rs. 50.00 Cr
2.Introduce pricing regulation for use of piped water for domestic use and drinking water	PHE	i. Feasibility studies ii Implementation	Rs.1.00 Cr
3. Undertake periodical census of medium and minor irrigation projects to check sustainability	IWRD	i. One Survey in 12th plan ii. One survey in 13th Paln	Rs.10.00 Cr

and also to detect dis-functionalities and implement remedial measures			
4. Introduce variable water tax for irrigation purpose on both use of underground water and surface water sources in the short term and the in the long term metering of water usage may be done obtained from canals as well as from centralised underground sources	IWRD WRIDD	i. Study on pricing structure keeping in view the potential of payment of the different farmer categories	Rs.2.00 Cr
5. Extend compulsory rain water harvesting regulations for all houses in cities and town in WB	SWID Municipal Corporation of different towns and cities	i. Design to be developed for different housing types in different regions ii. Create incentive schemes for the same iii. Implement 25% of all towns in WB	i+ii Rs.6.00 Cr (@Rs.1.00 Cr. for 6 regions) iii.Rs.100.00 Cr